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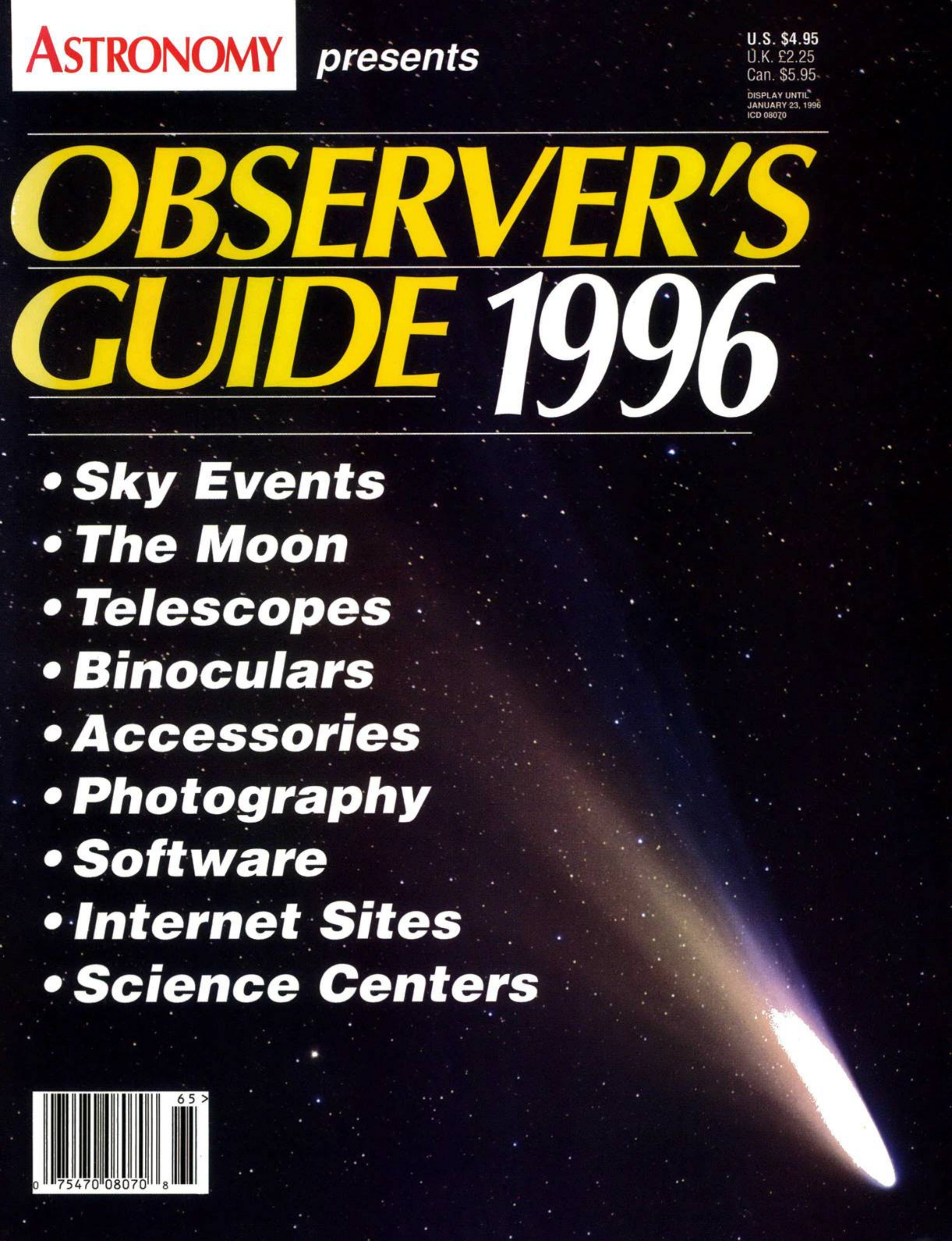

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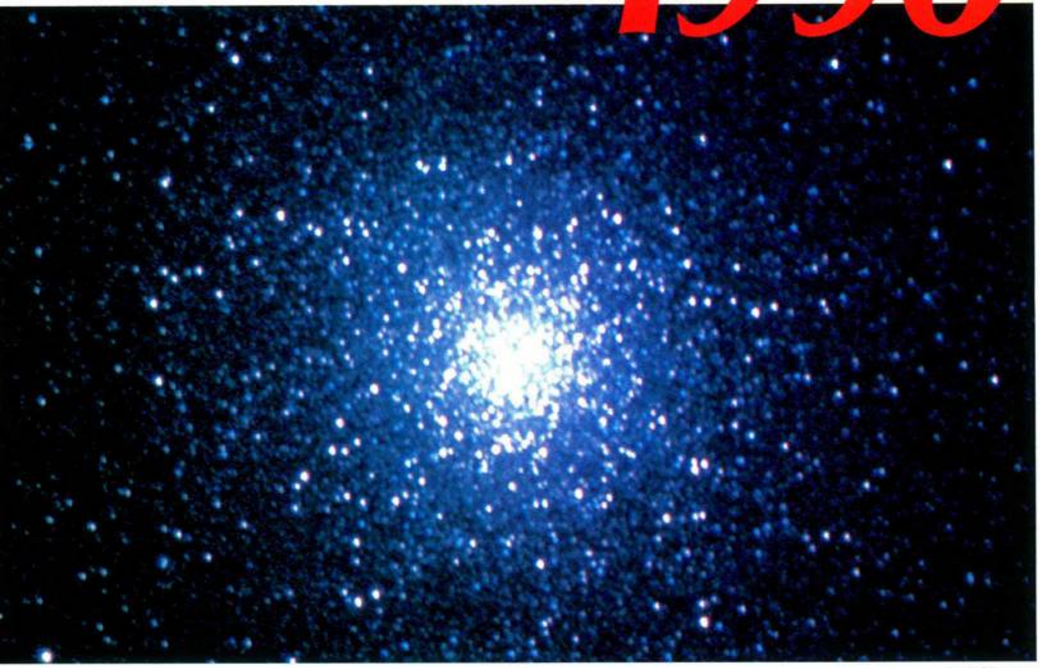


Jack Newton

Donald Parke

6 1996 Sky Guide

Be prepared when the Sun goes down. Your complete guide to sky events in 1996 tells you how, when, and where to see the Moon, stars, planets, comets, meteor showers, eclipses, and more. By John Shibley and Richard Talcott.

30 Selecting the Right Telescope, Binoculars, and Eyepieces

Buying your first telescope — or your second or third — can be a trying experience. But our guide on over 200 telescopes will help you make your purchase an exciting one. And if it's accessories, eyepieces, and binoculars you're after, we can point you in the right direction. By Alan Dyer.

64 Space Places

Observatories, planetariums, and science centers — where would you like to go on your next astronomical vacation? Here's a complete rundown of space places to make your trip an unforgettable adventure. By Tracy Staedter.

72 Computing the Sky

Check out the latest astronomy software that lets you explore the universe from the comfort of your own computer. Plot orbits, follow the lunar phases, or download astronomical images and news from the Internet. By David Bruning.

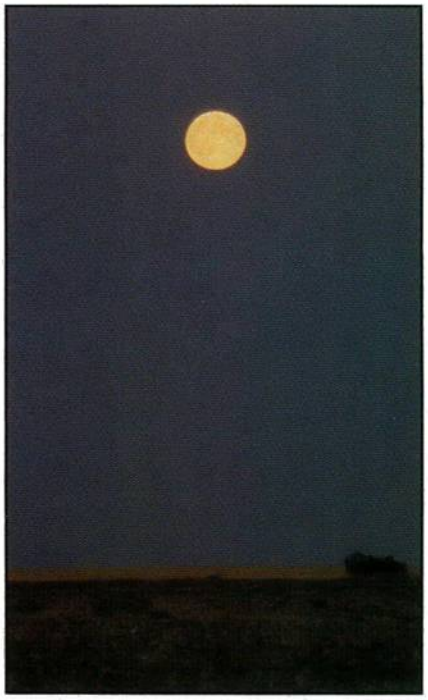
BRIGHT COMETS (like 1975's Comet West, on the cover) delight every backyard astronomer. The next bright one may be the newly discovered Comet Hale-Bopp, due to become a naked eye sight late in 1996 (see page 8). Photo by Ronald Royer and Steve Padilla.

88 Shooting the Sky With an Electronic Camera

A digital sky is never static. In just a few computer keystrokes, you can enhance or reveal details in celestial images captured in a few minutes' integration with a CCD and your very own 8-inch telescope. Here's how to get started. By Richard Berry.

98 Capture the Sky on Film

Maybe you prefer good old-fashioned emulsion to silicon, exposures to integrations, grains to pixels. Here's what you need to know to get up and running in astrophotography: tips on film, setup, exposure settings, and how to record sky objects worthy of framing. By Mark Coco.



Alan Dyer

102 Astrophoto Gallery

A panoply of some of the most sumptuous astrophotos from around the world. This collection of galaxies, star clusters, and nebulae celebrate the wonders of the visual universe.

Exploring Your Universe

Preston S. Justis

Is there any grander sight than a star-filled sky on a clear night? As you gaze upon the Milky Way — stars strewn like powder on velvet — you can almost feel infinity within your grasp. Astronomy is the oldest science and it's easy to see why: A starlit night is deeply awe-inspiring.

There's no better time than now for you to get involved with astronomy. Astronomers are making important discoveries almost daily, and humanity's exploration of our solar system continues apace. Likewise, in the realm of the backyard astronomer, there's never been a better array of equipment available to view the heavens with. Telescopes, eyepieces, binoculars, and all kinds of observing equipment provide an easy way for anyone to explore the sky for themselves.

Observer's Guide 1996 will help you get started. It was put together by the staff of ASTRONOMY, the leading magazine in the field. We've prepared a big section to tell you all about the coming year's celestial events. You'll also find guides to learning the constellations, exploring the Moon, and observing galaxies, nebulae, and star clusters — all exciting features of the universe.

You'll also find a practical guide to buying a telescope, whether it's your first scope or your twenty-first. And when it comes to observing accessories, we've got the pick of the market. Eyepieces? Binoculars? We have complete specifications and sound advice — all you need to make the best choices. The same goes for software, CD-ROMs, and the hottest resources on the Internet.

And if you, like many, long to capture the beauty of the night sky in photographs, you'll find articles telling you just how to do it, whether using film or the new electronic cameras that are fast-growing in popularity. Plus we have a beautiful showcase of some of the world's best astrophotography.

ASTRONOMY's *Observer's Guide 1996* is a passport to an adventure that lasts a lifetime — and which can take your imagination to the farthest reaches of the universe. Come and join us!

Robert Burnham
Editor

ASTRONOMY

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The Audit Bureau

ASTRONOMY'S 1996 SKYGUIDE

Imagine a sky in which nothing happens: no lunar or solar eclipses; no meteor showers; no comets or conjunctions; no seasonal changes. Night after night, you see the same immutable vault overhead. Sound exciting?

Such a flat-line universe would be as appealing as a dark, empty Broadway stage. Fortunately for us, the sky performs one of the greatest shows on Earth every clear night. To put yourself on the front row all you need to know is when and where to look.

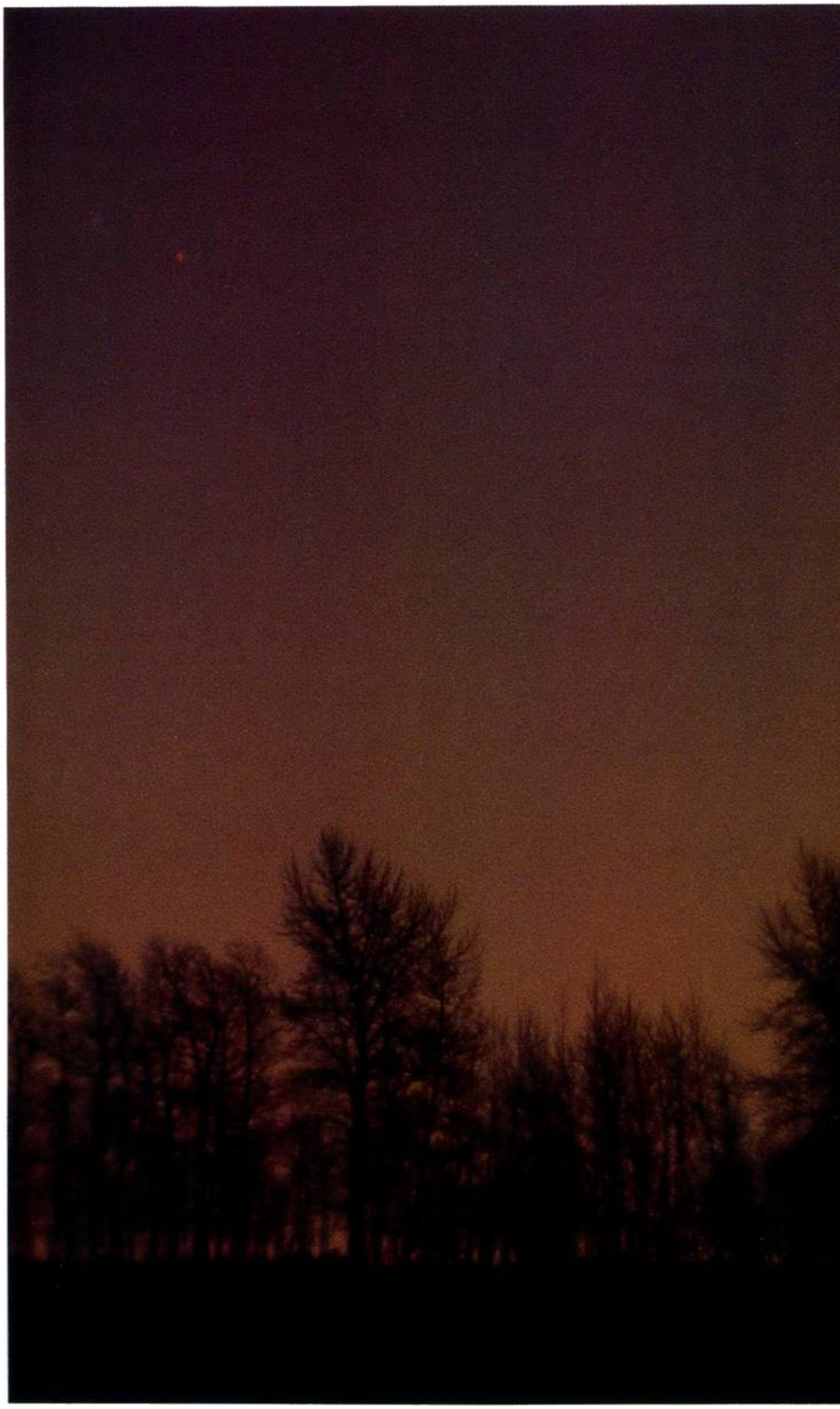
You hold in your hands the program guide to the sky for 1996, a complete agenda of eclipses, meteor showers, comets, and conjunctions visible to any backyard astronomer.

This year, Venus plays a major role in the evening twilight sky during the first four months of the year. Look for the planet less than a degree from the crescent Moon on February 22, and at its greatest angular distance from the Sun the last day of March. On May 4, Venus reaches greatest brilliancy, when it brightens enough to cast shadows at dark sky locations.

If you're looking for a little more drama in your observing, 1996 offers two fine lunar eclipses, both visible from the continental United States. The first debuts on the evening of April 3 and stretches into the early morning hours of April 4. For observers in the Eastern and Central time zones, the Moon rises totally eclipsed; western observers see the latter stages. The second lunar eclipse falls on the evening of September 26. Audiences in the Eastern and Central time zones can see the entire show this time, and those in the Mountain and Pacific time zones won't exactly be in the cheap seats! They, too, will have an excellent view of the Sun-Earth-Moon shadowplay.

After being upstaged by the Full Moon last year, the Perseid meteor shower assumes lead role in 1996, near New Moon. Thus, the fainter, faster members of this August shower won't be drowned out by moonlight. Will the Perseids put on a better-than-average display? The only way to find out is to see the shower for yourself.

No matter what "shows" you plan to see — or participate in — don't forget your *1996 Observer's Guide* on opening night. Break a leg!



Two lunar eclipses, a well-timed meteor shower, and sterling performances by Mercury, Venus, Jupiter, and Saturn make 1996 a year of great astronomical expectations.

Alan Dyer

January

S	M	T	W	T	F	S
	1	2	3	4	○	6
7	8	9	10	11	12	◑
14	15	16	17	18	19	●
21	22	23	24	25	26	◐
28	29	30	31			

Day Time (EST)

1 **2 a.m.**
Mars passes 1.6° south of Neptune (evening)

2 **11 a.m.**
Mercury is at greatest eastern elongation (19°, evening)

4 Quadrantid meteor shower peaks (Full Moon)

7 **7 p.m.**
Mars passes 0.6° south of Uranus (evening)

12 **7 p.m.**
Mercury passes 3° north of Mars (evening)

15 **10 p.m.**
Neptune is in conjunction with the Sun

18 **3 p.m.**
The Moon passes 5° north of Jupiter
5 p.m.
Mercury is in inferior conjunction

21 **2 a.m.**
Uranus is in conjunction with the Sun

23 **3 a.m.**
The Moon passes 5° north of Venus
11 p.m.
The Moon passes 5° north of Saturn

25 **Midnight**
Asteroid Juno is in conjunction with the Sun

Events in **bold** are ones you won't want to miss.

All times in the calendars are eastern time.

"Morning" or "evening" at the end of a listing denotes that the event appears before sunrise or after sunset, respectively.

A Bright Comet at Last?

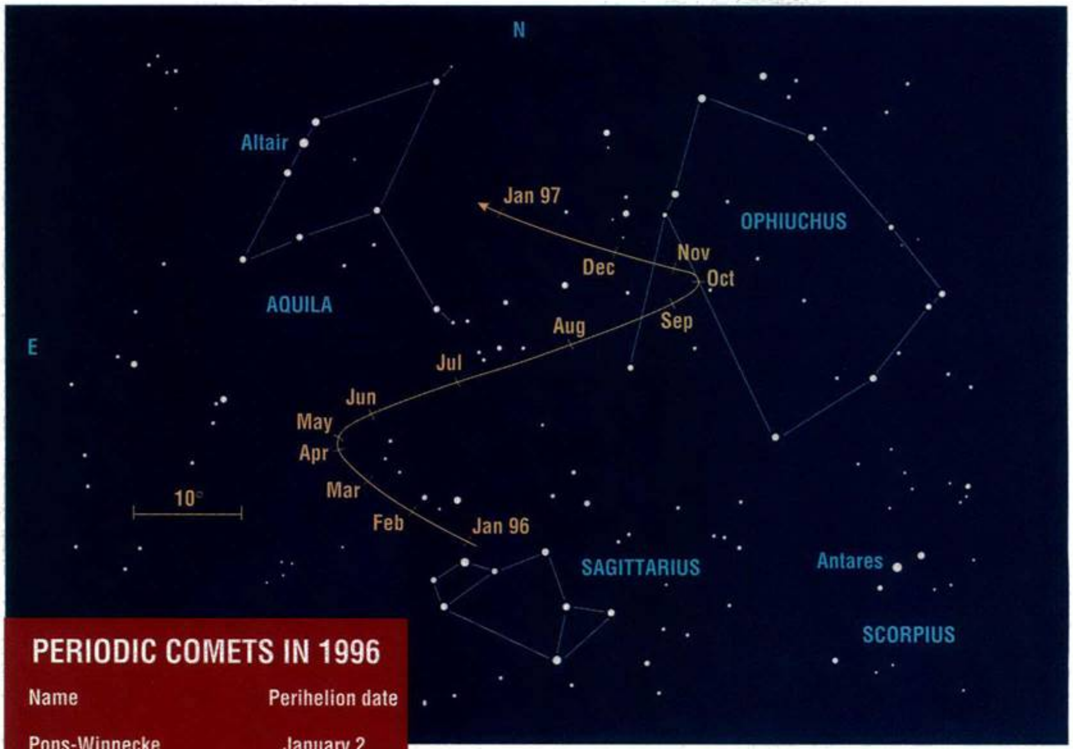
Twenty years after the magnificent appearance of Comet West, backyard observers may finally witness a worthy successor. Comet Hale-Bopp, a bright binocular object in early 1996, should grow to naked-eye visibility during the latter part of the year before peaking in the spring of 1997.

Hale-Bopp, discovered independently in July 1995 by amateur astronomers Alan Hale in Cloudcroft, New Mexico, and Thomas Bopp near Stanfield, Arizona, begins 1996 just north of the Teapot asterism in Sagittarius. That places it near the Sun in the sky, lost in the glare until late January, when it appears very low in the southeast just before sunrise. The comet becomes better placed by spring, appearing well up in the southeast before dawn.

Summer and fall offer the best observing prospects of the year. By then Hale-Bopp has moved significantly north, cutting through the summer Milky Way constellations of Scutum, Serpens, and Ophiuchus, and lies high in the sky during the nighttime hours. It should be a bright binocular object then and may, if early predictions hold up, be faintly visible to the naked eye from a dark site.

COORDINATES FOR COMET HALE-BOPP

Date	R.A. (2000)	Dec.
January 1, 1996	18h53m	−25°08'
February 1	19h13m	−23°30'
March 1	19h30m	−21°45'
April 1	19h43m	−19°39'
May 1	19h44m	−17°23'
June 1	19h29m	−14°46'
July 1	18h55m	−11°56'
August 1	18h11m	−8°56'
September 1	17h40m	−6°36'
October 1	17h30m	−5°02'
November 1	17h41m	−3°21'
December 1	18h05m	−0°38'
January 1, 1997	18h44m	4°45'

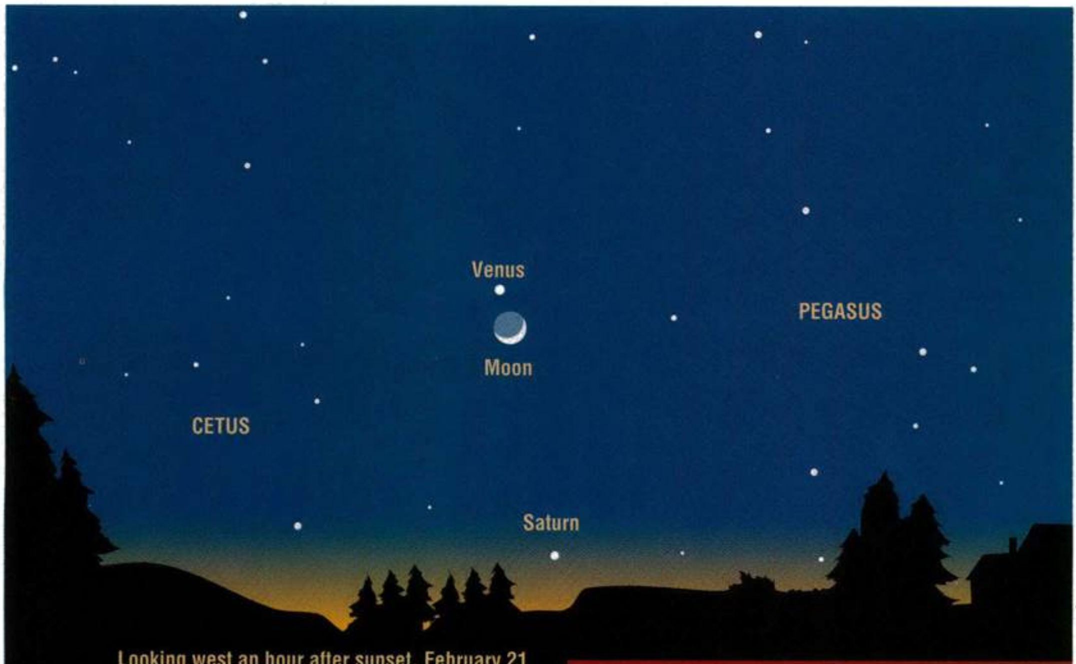


PERIODIC COMETS IN 1996

Name	Perihelion date
Pons-Winnecke	January 2
Churyumov-Gerasimenko	January 17
Chiron	February 14
du Toit-Neujmin-Delporte	March 5
Mueller 1	April 25
West-Hartley	May 12
Comas Sola	June 10
Parker-Hartley	June 25
Kopff	July 2
Gunn	July 24
Shoemaker-Holt 2	August 20
Wild 4	August 31
Machholz	October 15
Helin-Roman-Crockett	November 1

Hale-Bopp won't be at its best, however, until spring 1997, when it comes closest to both the Sun and Earth. By that time it has moved even farther north and will be racing through Andromeda. Some astronomers think it could then rival the brighter stars, although predicting how bright a newly discovered comet will become is far from an exact science. Keep your eyes turned to the sky — and to the pages of ASTRONOMY — to learn the latest on what could be the observing highlight of the next two years.

Dining on Earthshine



Looking west an hour after sunset, February 21

CONJUNCTIONS BETWEEN THE MOON AND PLANETS IN 1996

Date	Planet	Time Best Seen
Jan. 24	Saturn	evening
Feb. 21	Venus	evening
May 13	Saturn	morning
June 4	Jupiter	morning
July 1	Jupiter	morning
July 12	Venus	morning
Sept. 21	Jupiter	evening
Sept. 26	Saturn	evening
Oct. 24	Saturn	evening
Dec. 8	Venus	morning

One of nature's most wonderful sights happens when the Moon appears to pass close to a planet in the sky, creating what skywatchers call a conjunction. This event offers a fine opportunity to compare worlds through a telescope. It also lets you locate nearby planets or bright stars using the Moon as a convenient signpost. But in the purest sense a conjunction is just plain beautiful, and the one that occurs February 21 is no exception.

That evening the three-day-old Moon becomes visible after sunset, followed shortly by brilliant, –4.2-magnitude Venus to the upper left of the Moon. Because Venus is so bright, try finding it as soon as you locate the Moon just after sunset. You should be able to spot it while the sky is still very light, long before any other stars appear.

After the sky darkens to where bright stars come out, look for Saturn well below and to the right of the Moon. The ringed planet shines at the comparatively paltry magnitude of 1.2, still suffering from the effects of having its rings presented nearly edge-on. In years when the rings are wide open, they contribute about half a magnitude to the planet's overall brightness.

After noting the ring(less) planet, turn your attention back to the Moon. You'll notice immediately that its unlit portion appears bathed in an eerie, bluish glow. This is "earthshine," sunlight reflected from Earth's clouds and oceans onto the Moon. Earthshine gets harder to spot after the 21st for two reasons. First, the Moon's sunlit portion gets fatter and creates more glare. Second, as the Moon moves in its orbit around Earth it sees more of our planet's nightside and, consequently, has less sunlight reflected to it.

While it lasts, earthshine makes an interesting photographic target. Load ISO 200 film into a camera fitted with at least a 50mm lens set to f/5.6. Compose the sky in the viewfinder along with any interesting foreground objects. Then capture the scene with exposures of up to ten seconds.

Daniel McGlaun

February

S	M	T	W	T	F	S
				1	2	3
○	5	6	7	8	9	10
11	◑	13	14	15	16	17
●	19	20	21	22	23	24
25	◐	27	28	29		

Day Time (EST)

2 9 p.m.
Venus passes 1.3° north of Saturn (evening)

11 9 a.m.
Mercury passes 0.07° north of Neptune (morning)
4 p.m.
Mercury is at greatest western elongation (26°, morning)
9 p.m.
Earth passes through the ring-plane of Saturn

15 10 a.m.
The Moon passes 5° north of Jupiter

16 3 p.m.
The Moon passes 5°north of Neptune
5 p.m.
Mercury passes 0.2° north of Uranus (morning)
Midnight
The Moon passes 6° north of Uranus

17 1 a.m.
The Moon passes 5° north of Mercury

20 2 p.m.
The Moon passes 4° north of Saturn

21 Midnight
The Moon passes 0.06° south of Venus

March

S	M	T	W	T	F	S
					1	2
3	4	○	6	7	8	9
10	11	◑	13	14	15	16
17	18	●	20	21	22	23
24	25	◐	27	28	29	30
31						

Day Time (EST)

4 **9 a.m.**
Mars is in conjunction with the Sun

14 **1 a.m.**
The Moon passes 5° north of Jupiter
Midnight
The Moon passes 5° north of Neptune

15 **11 a.m.**
The Moon passes 6° north of Uranus

17 **2 p.m.**
Saturn is in conjunction with the Sun

20 **3 a.m.**
Equinox (northern spring/southern autumn begins)

22 **7 p.m.**
The Moon passes 5° south of Venus

28 **3 a.m.**
Mercury is in superior conjunction

31 **8 p.m.**
Venus is at greatest eastern elongation (46°,evening)

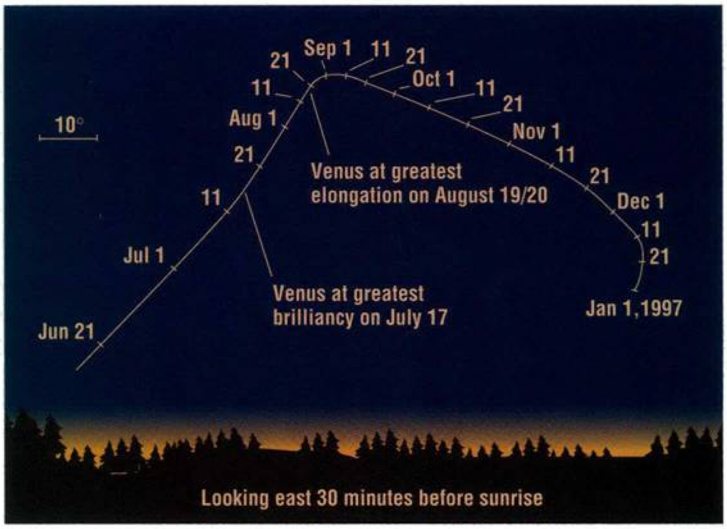
Venus Bright in the Evening

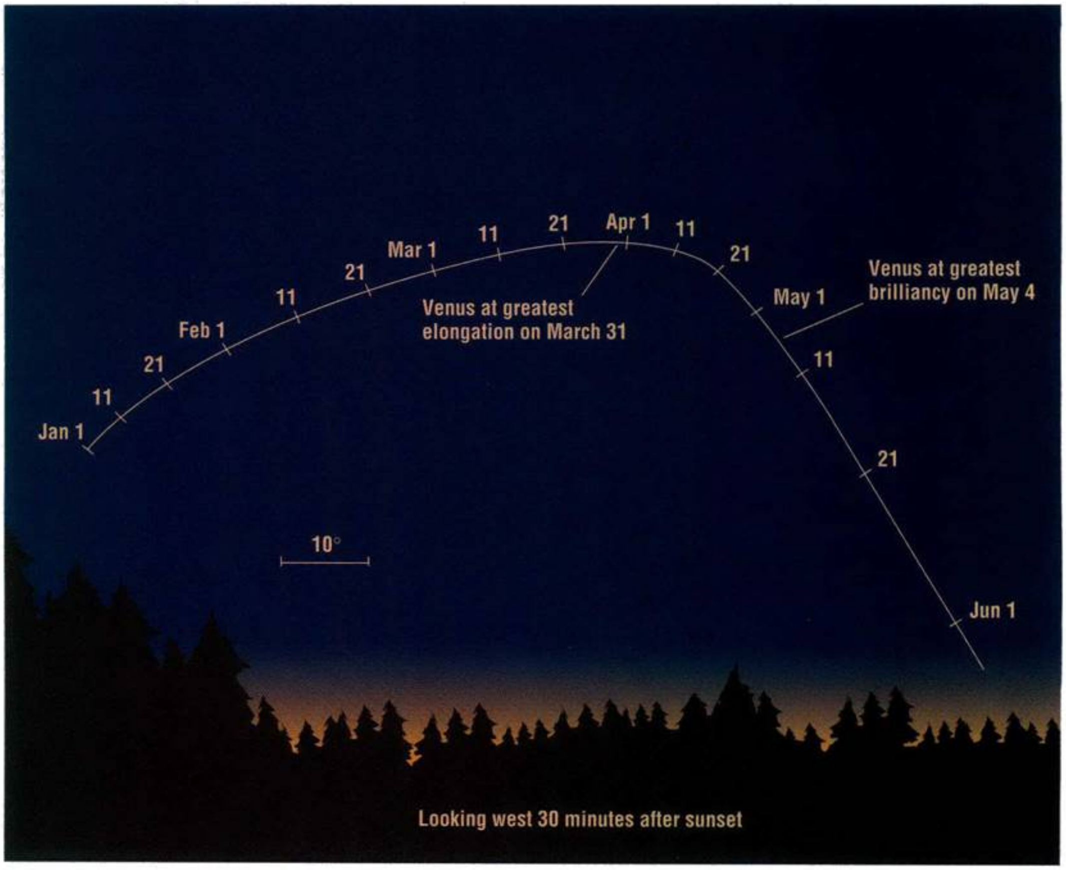
As darkness falls on these spring evenings, the brilliant point of light in the west is Venus. Outshining every object except the Moon, Venus dominates the evening sky from the beginning of the year until late May. The peak of this current apparition occurs in March and April.

Venus began the year fairly low in the southwest, but it quickly gained altitude as it moved to the north. On March 1 it lies 35° high in the west half an hour after the Sun sets and remains prominent long after the sky grows dark. It slowly climbs higher as it approaches greatest elongation on March 31, when it lies 46° east of the Sun and shines brilliantly at magnitude –4.4. During April the planet slowly begins to sink toward the twilight glow, a motion that accelerates during May.

Although you don't need anything beyond your naked eye to appreciate Venus, a telescope reveals its rapidly changing size and phase. During the first five months of the year, as Earth draws closer to Venus, the planet's apparent size grows and its phase wanes. During March its apparent diameter increases from 18" to 23" across and its phase shrinks from 66 percent to 51 percent. By the end of April, Venus measures 34" across and is 32 percent lit and a month later it appears a whopping 55" across but just 4 percent lit.

After passing between the Sun and Earth in June, Venus shoots into the morning sky for another spectacular apparition. You can find the dazzling object in the east before dawn from late June until the end of the year.





Red Moon Rising

A FULL MOON WILL RISE IN ECLIPSE April 3 for people along the east coast. Here, under similar circumstances, an eclipsed Moon rises over the Jefferson Memorial in Washington, D.C.

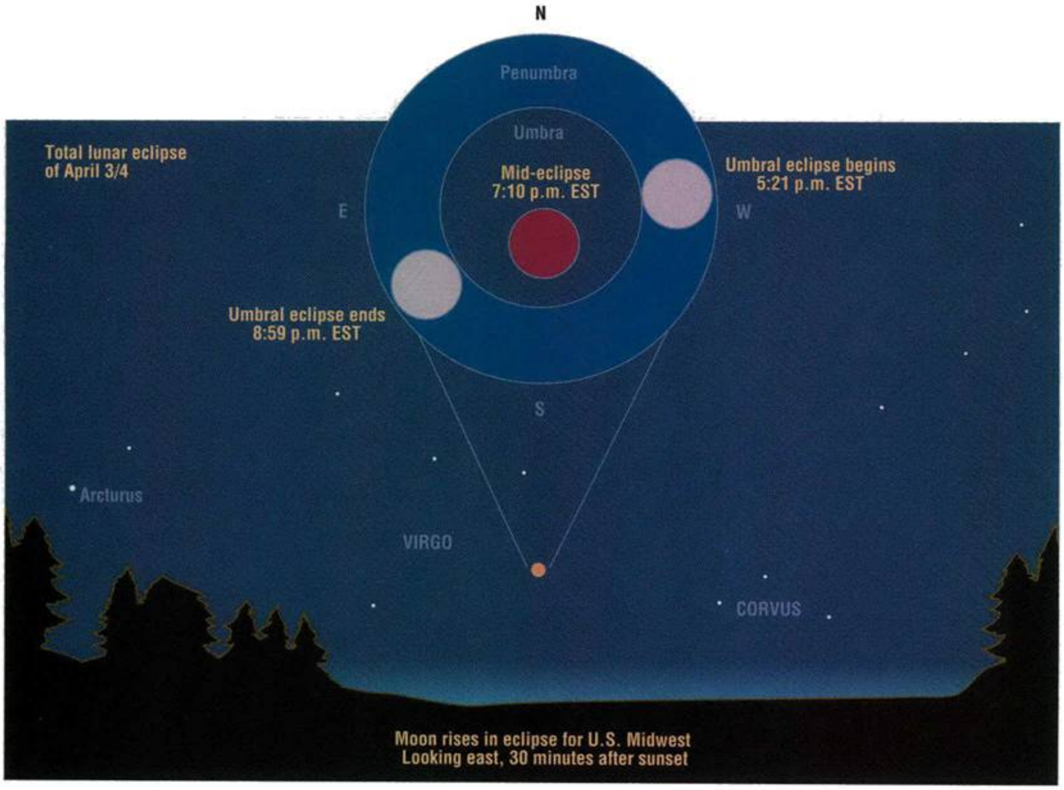
Andre Bormanis

Observers in North America have front-row seats to a pair of lunar eclipses during 1996, one in April and the other in September. While both provide stunning views of the Moon passing through our planet's shadow, it's the April event that offers the enchanted sight of an eclipsed Moon rising during sunset. As the sky darkens and the Moon rises higher, it will appear bathed in a red glow from all the Earthly sunrises and sunsets happening at that moment.

Those living between the Eastern Seaboard and the Midwest are favorably placed to see the Moon rise completely immersed in shadow, which happens between 6:26 p.m. EST and 7:53 p.m. EST on April 3. Observers west of a line that runs through the northwestern corner of Minnesota, the Iowa-Nebraska state line, the eastern third of Kansas, the eastern half of Oklahoma, and the eastern third of Texas see the Moon rise after totality has ended.

While this may come as a disappointment to western skywatchers, they should keep this in mind: It is their sunset and late afternoon skyglow that is casting totality's warm light on our natural satellite. As consolation, people in the Great Plains and the eastern Rockies will glimpse the Moon before it fully leaves the umbral shadow, which happens at 8:59 p.m. EST. People west of the Rockies see the Moon in penumbral eclipse, before the whole event wraps up at 10:08 p.m. EST (7:08 p.m. PST).

Because April's lunar eclipse happens so close to the horizon, try photographing it with interesting foreground objects like trees or monuments. Use a telephoto lens that has a focal length greater than 500mm to "squeeze" the Moon together with the terrestrial target you choose. Using a camera loaded with ISO 200 film, set the lens to f/8 and shoot a variety of shutter speeds centered on 1/250 of a second. When the sky is darker, open up your lens to f/5.6 to capture the Moon's eerie red glow by exposing up to 4 seconds. ASTRONOMY, of course, welcomes any pictures you care to send us.


N
Penumbra
Umbra
Total lunar eclipse of April 3/4
Mid-eclipse 7:10 p.m. EST
Umbral eclipse begins 5:21 p.m. EST
E
W
Umbral eclipse ends 8:59 p.m. EST
S
Arcturus
VIRGO
CORVUS

Moon rises in eclipse for U.S. Midwest
Looking east, 30 minutes after sunset

April

S	M	T	W	T	F	S
	1	2	○	4	5	6
7	8	9	◑	11	12	13
14	15	16	●	18	19	20
21	22	23	24	◐	26	27
28	29	30				

Day	Time (EDT, after April 7)
3	7 p.m. **Total lunar eclipse**
7	2 a.m. Daylight saving time begins
8	8 a.m. The Moon passes 1.0° south of Ceres
10	1 p.m. The Moon passes 5° north of Jupiter
11	8 a.m. The Moon passes 5° north of Neptune 8 p.m. The Moon passes 6° north of Uranus
15	6 p.m. Venus passes 10° north of Aldebaran 9 p.m. The Moon passes 4° north of Saturn
17	7 p.m. Partial solar eclipse
18	5 p.m. **Asteroid Pallas is at opposition**
19	6 a.m. The Moon passes 5° south of Mercury
21	10 a.m. The Moon passes 9° south of Venus **Lyrid meteor shower peaks (New Moon)**
23	4 a.m. **Mercury is at greatest eastern elongation (20°, evening)**

May

S	M	T	W	T	F	S
			1	2	○	4
5	6	7	8	9	◑	11
12	13	14	15	16	●	18
19	20	21	22	23	24	◐
26	27	28	29	30	31	

Day Time (EDT)

4 **10 a.m.**
Venus is at greatest brilliancy (magnitude –4.5)
Eta Aquarid meteor shower peaks (Full Moon)

5 **11 a.m.**
The Moon passes 0.3° south of Ceres

7 **8 p.m.**
The Moon passes 5° north of Jupiter

8 **1 p.m.**
The Moon passes 5° north of Neptune
5 p.m.
Asteroid Vesta is at opposition

9 **2 a.m.**
The Moon passes 6° north of Uranus

13 **9 a.m.**
The Moon passes 3° north of Saturn

14 **9 p.m.**
Mercury is in inferior conjunction

15 **11 p.m.**
The Moon passes 1.7° south of Mars

19 **9 p.m.**
The Moon passes 8° south of Venus

22 **10 a.m.**
Pluto is at opposition

29 **8 p.m.**
Asteroid Ceres is at opposition

31 **2 a.m.**
Mercury passes 4° south of Mars (morning)

Spot a Pair of Bright Asteroids

May ranks as a special month for observers of asteroids, as the two brightest glow brightly the whole night long. Asteroids, or minor planets as they are sometimes called, are rocky members of the solar system too small to be called planets. Although most of the more than ten thousand asteroids glow feebly and can be glimpsed only with a telescope, this month you can easily locate Ceres and Vesta with a pair of binoculars and, if you observe from a dark site, spot Vesta with the naked eye.

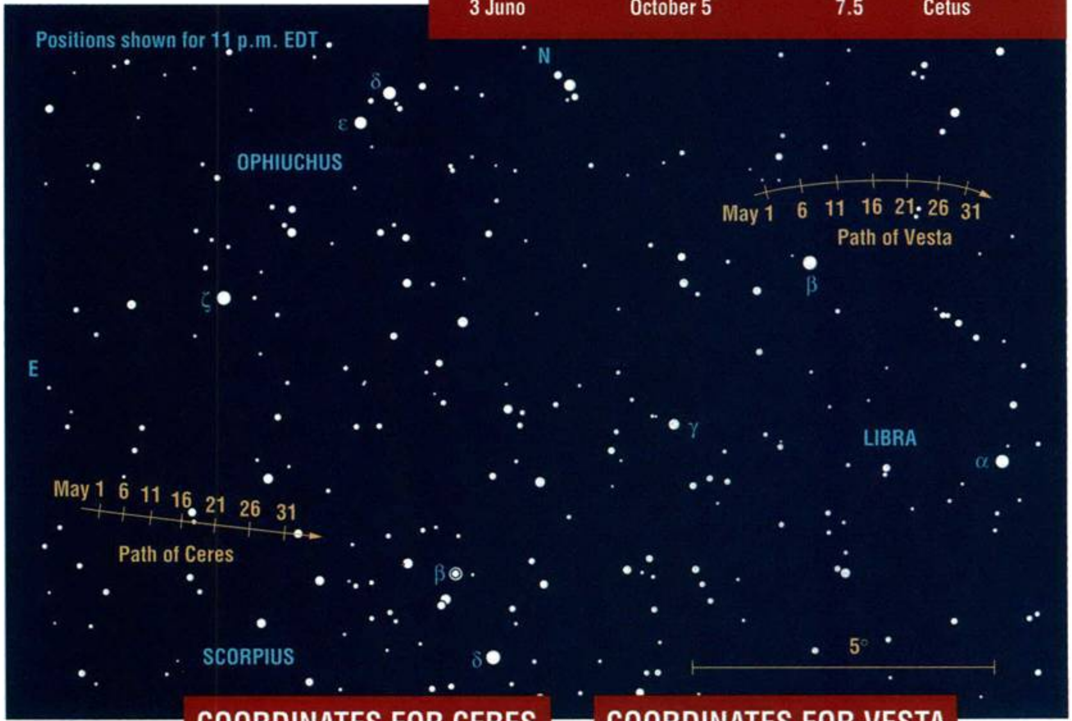
Asteroids 1 Ceres and 4 Vesta come to opposition on May 30 and 8, respectively. At opposition the asteroids lie closest to Earth and thus appear brightest. Ceres glows at magnitude 7.0 at opposition and Vesta, the brightest of all, shines at magnitude 5.6.

The two are also relatively close to one another in the sky, located about 25° apart. Ceres, the largest asteroid with a diameter of about 600 miles, moves slowly westward through southern Ophiuchus. Vesta's westerly motion carries it through northern Libra. Although it is smaller than Ceres, ranking third among asteroids at about 330 miles across, it appears brighter because it is closer to Earth and has a more reflective surface.

Use the finder chart to locate the approximate areas of the asteroids. (Positions are shown for 11 p.m. EDT, 10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT.) Then turn your binoculars on those regions and pick out Ceres and Vesta. And once you've located Vesta, set the binoculars aside and see if you can spot it with the eye alone.

ASTEROIDS IN 1996

Name	Opposition date	Magnitude	Constellation
14 Irene	January 20	9.1	Cancer
532 Herculina	February 18	8.8	Leo Minor
44 Nysa	February 29	9.1	Leo
20 Massalia	March 8	8.8	Leo
2 Pallas	April 18	8.3	Bootes
4 Vesta	May 8	5.6	Libra
1 Ceres	May 30	7.0	Ophiuchus
12 Victoria	July 19	8.7	Aquila
192 Nausikaa	August 7	9.0	Capricornus
21 Lutetia	August 16	9.3	Capricornus
39 Laetitia	August 21	9.1	Aquarius
3 Juno	October 5	7.5	Cetus



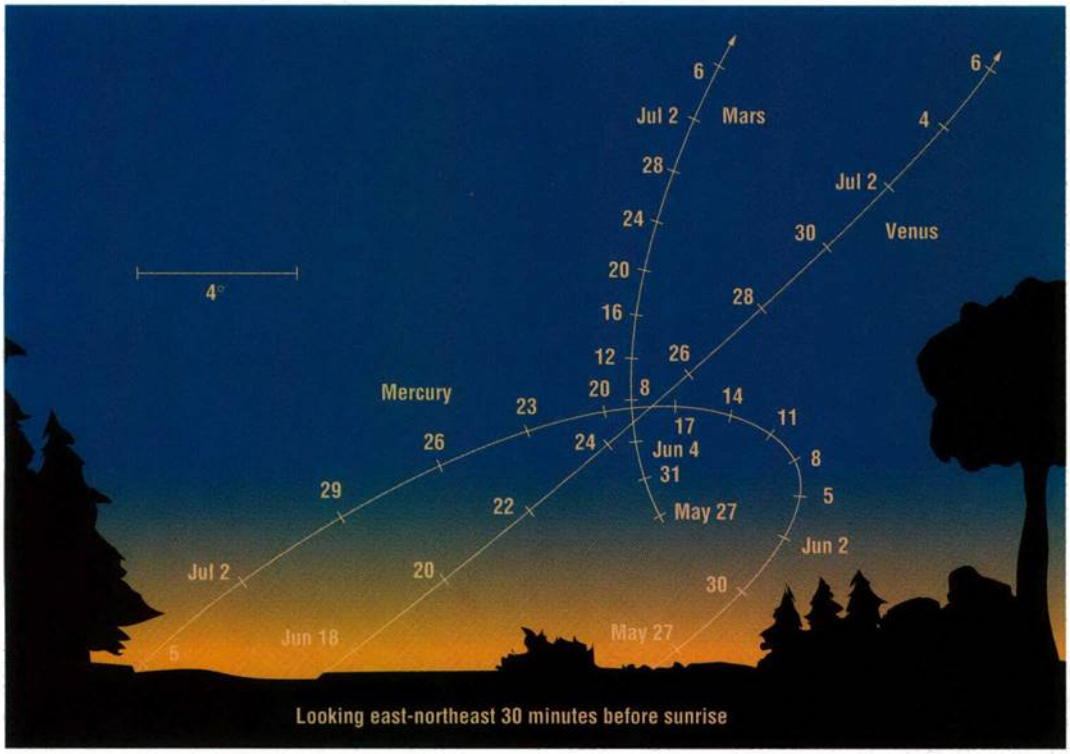
COORDINATES FOR CERES

Date	R.A. (2000)	Dec.
May 1	16h54.3m	–17°43'
May 6	16h51.0m	–17°50'
May 11	16h47.2m	–17°57'
May 16	16h43.0m	–18°04'
May 21	16h38.5m	–18°11'
May 26	16h33.7m	–18°19'
May 31	16h28.9m	–18°26'

COORDINATES FOR VESTA

Date	R.A. (2000)	Dec.
May 1	15h22.9m	–7°00'
May 6	15h18.1m	–6°50'
May 11	15h13.2m	–6°42'
May 16	15h08.4m	–6°38'
May 21	15h03.7m	–6°38'
May 26	14h59.4m	–6°42'
May 31	14h55.6m	–6°51'

Catch Mercury Before Dawn



Looking east-northeast 30 minutes before sunrise

Elusive Mercury puts on a good show in the predawn sky throughout June. The innermost planet has a reputation for being elusive not because it is faint — it shines brightly at magnitude 0 during most of June — but because it never rises out of the twilight glow. This month, however, Mercury climbs higher than normal and becomes fairly well-placed in the morning sky.

Spotting Mercury this month requires a sky devoid of low clouds or haze and an unobstructed horizon toward the east-northeast. The best time to find it is 30 minutes before sunrise, when it has climbed high enough to be seen but glare from the approaching dawn is not yet severe. With binoculars, scan just above the horizon, looking for an orangish point of light. Once you've located it, set the binoculars aside and see if you can pick it up with your naked eye.

From June 7 to 26, Mercury appears more than 5° above the horizon half an hour before sunrise. It reaches greatest elongation on June 10, when it lies 24° west of the Sun. It actually climbs a little higher in the sky, however, during the following two weeks.

You'll get some help in finding it on June 22 and 23, when brilliant Venus passes just 2° below Mercury. Venus shines some 30 times brighter than Mercury and will easily guide you to the fainter planet. Mars also lies in this vicinity, not far above Mercury, around mid-June. You should be able to tell the two apart because Mercury is noticeably brighter.

Brian Skiff

WHEN TO SEE MERCURY IN 1996

EVENING Greatest elongation	Visible from	Maximum altitude
January 2 (19°)	Jan. 1 to Jan. 13	9°
April 23 (20°)	Apr. 6 to May 5	13°
August 21 (27°)	Jul. 19 to Sep. 11	5°
December 15 (20°)	Nov. 19 to Dec. 27	8°

MORNING Greatest elongation	Visible from	Maximum altitude
February 11 (26°)	Jan. 25 to Mar. 19	8°
June 10 (24°)	May 24 to Jul. 4	7°
October 3 (18°)	Sep. 25 to Oct. 20	11°

Maximum altitude is for an observer at 40° north latitude either 30 minutes after sunset or 30 minutes before sunrise.

June

S	M	T	W	T	F	S
						○
2	3	4	5	6	7	◑
9	10	11	12	13	14	●
16	17	18	19	20	21	22
23	◐	25	26	27	28	29
○						

Day Time (EDT)

4 **2 a.m.**
The Moon passes 5° north of Jupiter
8 p.m.
The Moon passes 5° north of Neptune

5 **8 a.m.**
The Moon passes 6° north of Uranus

9 **6 p.m.**
The Moon passes 3° north of Saturn

10 **5 a.m.**
Mercury is at greatest western elongation (24°, morning)
Noon
Venus is in inferior conjunction

13 **8 p.m.**
The Moon passes 0.4° south of Mercury
9 p.m.
The Moon passes 4° south of Mars

14 **9 a.m.**
Mercury passes 3° south of Mars (morning)

20 **10 p.m.**
Solstice (northern summer/southern winter begins)

21 **7 a.m.**
Mercury passes 4° north of Aldebaran (morning)

23 **8 a.m.**
Mercury passes 1.6° north of Venus (morning)

27 **8 a.m.**
Mars passes 6° north of Aldebaran (morning)

29 **Midnight**
Venus passes 4° south of Mars (morning)

July

S	M	T	W	T	F	S
	1	2	3	4	5	6
◑	8	9	10	11	12	13
14	●	16	17	18	19	20
21	22	◐	24	25	26	27
28	29	○	31			

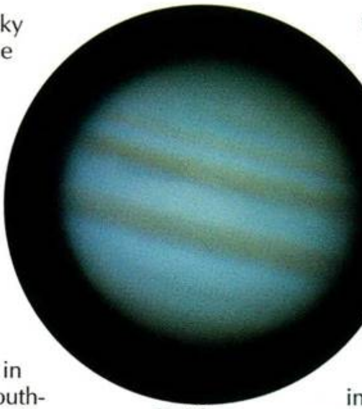
Day	Time (EDT)
1	**6 a.m.** The Moon passes 5° north of Jupiter
2	**4 a.m.** The Moon passes 4° north of Neptune **4 p.m.** The Moon passes 5° north of Uranus
4	**8 a.m.** **Jupiter is at opposition**
7	**2 a.m.** **The Moon passes 3° north of Saturn**
11	**5 a.m.** Mercury is in superior conjunction
12	**5 a.m.** **The Moon passes 0.4° north of Venus** **7 p.m.** The Moon passes 5° south of Mars
17	**5 a.m.** **Venus is at greatest brilliancy (magnitude –4.5)**
18	**2 p.m.** **Neptune is at opposition**
25	**3 a.m.** **Uranus is at opposition**
28	Southern Delta Aquarid meteor shower peaks (Full Moon) **Noon** The Moon passes 5° north of Jupiter
29	**2 p.m.** The Moon passes 4° north of Neptune **Midnight** The Moon passes 5° north of Uranus

Jupiter Visits the Milky Way

The glorious vistas of the Milky Way normally command the attention of backyard observers on sultry summer evenings. But this summer the Milky Way has competition from the bright planet Jupiter, which lies against the rich stellar background of Sagittarius, just north of the Teapot asterism. It will appear at its best both visually and telescopically during June and July.

Jupiter begins the year very low in the east before dawn. It skirts the southern edge of the Trifid Nebula (M20), a large cloud of gas and dust in the Milky Way, during the year's first week, though the nebula is difficult to discern in the twilight. The giant planet rises earlier and climbs farther above the dawn throughout the winter and spring, setting the stage for summer's grand show. The peak of the 1996 apparition comes on July 4, when Jupiter lies opposite the Sun in our sky (an alignment known as opposition), rising at sunset, appearing highest in the south around midnight, and setting at sunrise.

Because Jupiter lies closest to Earth at opposition, it also appears at its brightest (shining brilliantly at magnitude –2.7) and largest (47" in diameter) for the year. Even a small telescope will reveal the alternating series of dark belts and light zones that girdle the planet and the never-ending dance of the four large Galilean satellites.

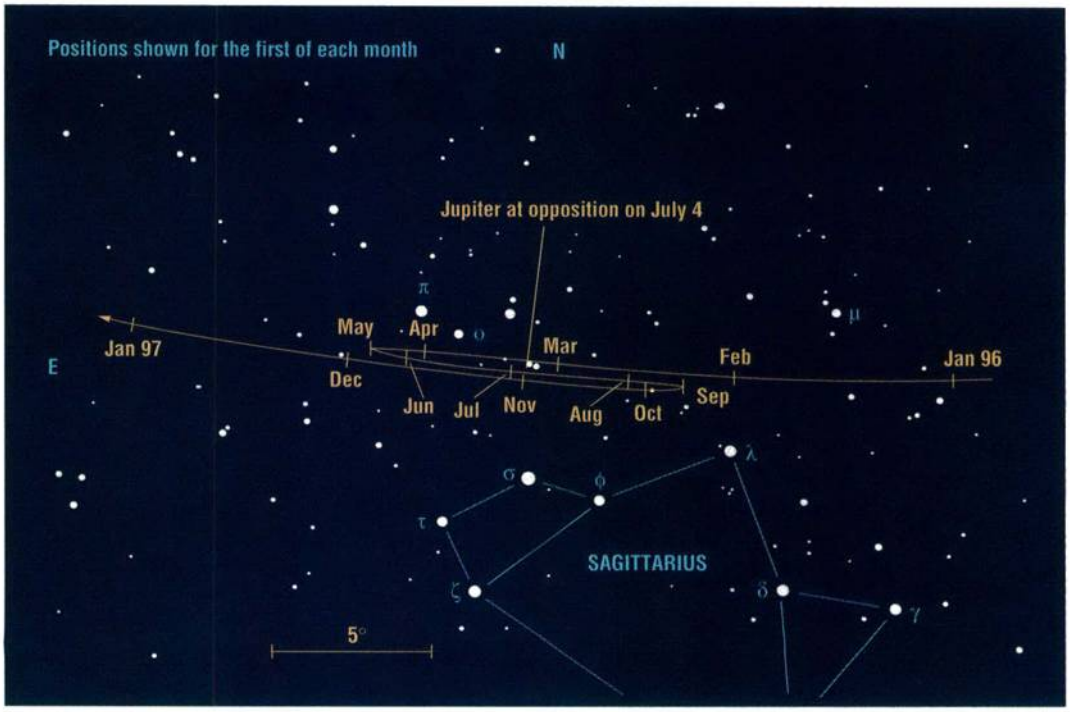

Mark Coco

Galileo entered orbit around Jupiter on December 7, 1995. Here are the close approaches it will make to the satellites during 1996:

Date	Satellite	Minimum distance (km)
July 4	Ganymede	500
July 5	Europa	186,000
September 6	Ganymede	255
November 4	Callisto	1,100
November 6	Europa	31,947
December 19	Europa	695

DON'T OVERLOOK URANUS AND NEPTUNE

While Jupiter dominates these summer nights, two lesser solar system lights are also worth a look. The gas giants Uranus and Neptune come to opposition within a week of each other in the latter half of July. They lie 7° apart, with Uranus residing in western Capricornus and Neptune in eastern Sagittarius. You can spot Uranus with the naked eye from a dark site, glowing softly at 6th magnitude, but you'll need binoculars to glimpse 8th-magnitude Neptune.


Positions shown for the first of each month
N
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Jupiter at opposition on July 4
Jan 97
May
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Mar
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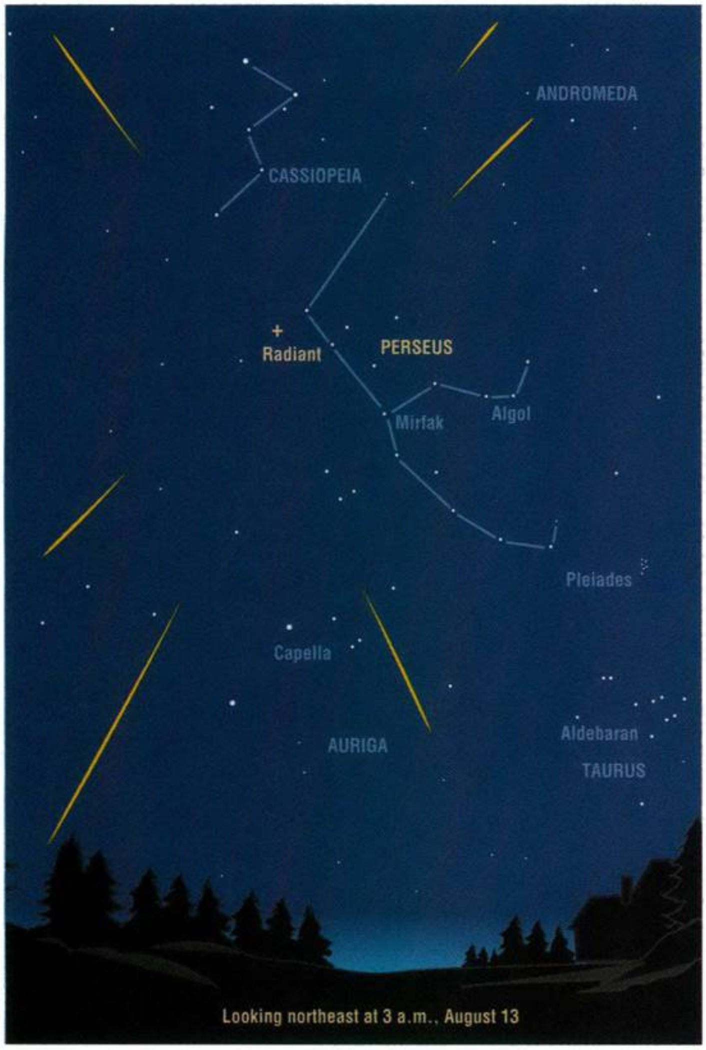
A Midsummer Night's Tears



Looking northeast at 3 a.m., August 13

Tom Stafford

CATCH A FLEETING PERSEID by loading a tripod-mounted camera with ISO 400 film fitted to a 50mm lens. Aim the camera overhead or northeast, focus the lens on infinity, and take a 10-minute exposure.

Ah, the dog days of August. Baseball, swimming, hamburgers, and . . . meteors. To veteran skywatchers, August is indeed a month for one of the year's most active meteor showers, the Perseids. Every summer for four days straddling August 13, Earth passes through a dense debris cloud left in the wake of Comet Swift-Tuttle.

While most of this cometary debris is no larger than a grain of sand, some are the size of baseballs and watermelons. It's the grains that cause most "shooting stars" seen during a Perseid meteor shower, up to 100 per hour. After hitting Earth's atmosphere at 59 km per second, friction causes them to burn up in a flash of light. The larger meteoroids blaze brighter and leave luminescent trails called "trains."

The Perseids get their name from Perseus, the constellation from which they appear to emanate. Perseus starts the evening low in the northeast, but as night progresses it climbs higher in the sky. Just before daybreak it lies nearly overhead.

The best time to witness any meteor shower is early morning, beginning around 2 a.m. That's when the leading edge of Earth (in its orbit around the Sun) plows directly into the debris cloud. Meteors seen earlier in the evening have to actually catch up with the orbiting Earth before plunging into the atmosphere. Morning meteors are literally swept up by Earth to their fiery fate.

Humans have known of this shower for ages. In medieval times Perseids were the scalding tears of St. Lawrence, a Christian deacon martyred over a red-hot gridiron by the Romans in August 258. Today the "tears" might appear in any part of an August night sky, but drawing a line back along their line of travel reveals their current namesake, Perseus.

METEOR SHOWERS FOR 1996

Name	Peak date	Peak time (UT)	Duration
Quadrantids	Jan. 3	12.8h	14 hours to 1 day
Lyrids	April 22	21.4h	2.3 days
Eta Aquarids	May 5	20.6h	3 days
Delta Aquarids	July 28	11.2h	broad
Perseids	Aug. 12	9.6h	4.6 days
Orionids	Oct. 21	13.9h	2 days
Leonids	Nov. 17	10.2h	4 days
Geminids	Dec. 13	16.3h	2.6 days

August

S	M	T	W	T	F	S
				1	2	3
4	5	◑	7	8	9	10
11	12	13	●	15	16	17
18	19	20	◐	22	23	24
25	26	27	○	29	30	31

Day	Time (EDT)
1	6 a.m. Mercury passes 0.5° north of Regulus
3	9 a.m. **The Moon passes 3° north of Saturn**
8	3 a.m. **The Moon passes 1.0° north of Aldebaran**
9	Midnight **The Moon passes 1.2° south of Venus**
10	5 p.m. The Moon passes 6° south of Mars
12	**Perseid meteor shower peaks (New Moon)**
16	2 p.m. The Moon passes 0.3° south of Mercury
19	Midnight **Venus is at greatest western elongation (46°, morning)**
21	Noon Mercury is at greatest eastern elongation (27°, evening) 3 p.m. The Moon passes 0.9° north of Vesta
24	6 p.m. **The Moon passes 5° north of Jupiter**
25	11 p.m. The Moon passes 5° north of Neptune
26	9 a.m. The Moon passes 5° north of Uranus
30	5 p.m. The Moon passes 3° north of Saturn
31	1 p.m. Mars passes 6° south of Pollux

September

S	M	T	W	T	F	S
1	2	3	◑	5	6	7
8	9	10	11	●	13	14
15	16	17	18	19	◐	21
22	23	24	25	○	27	28
29	30					

Day	Time (EDT)
2	1 a.m. Venus passes 9° south of Pollux
4	**10 a.m.** **The Moon passes 0.9° north of Aldebaran** **11 a.m.** **Venus passes 3° south of Mars (morning)**
8	3 p.m. The Moon passes 6° south of Mars 7 p.m. The Moon passes 3° south of Venus
17	9 a.m. Mercury is in inferior conjunction
21	2 a.m. The Moon passes 6° north of Jupiter
22	7 a.m. The Moon passes 5° north of Neptune
22	2 p.m. Equinox (northern autumn/southern spring begins) 5 p.m. The Moon passes 6° north of Uranus
26	**3 p.m.** **Saturn is at opposition** **11 p.m.** **Total lunar eclipse** **Midnight** **The Moon passes 3° north of Saturn**

Shine (Off) Harvest Moon

Jacques Guertin

The longest total lunar eclipse for North American observers in more than seven years graces the early autumn night sky of September 26/27. For over five hours, the 3,475-kilometer-diameter Moon traverses the northern half of Earth's 16,500-kilometer-wide shadow. It misses the central part of our planet's shadow by a mere 2,300 kilometers, as measured from the center of the Moon's disk. Even when the Moon is completely immersed in the darkest part of Earth's shadow, the umbra, it still looks coppery red. This is the light from countless sunrises and sunsets shining from our planet onto the Moon.

Two factors may make the Moon look darker than the last well-placed total lunar eclipse North Americans saw on November 28, 1993. First, the Moon is only $2\frac{1}{2}$ days past perigee, it's closest point to Earth. This lets it dig through a darker portion of Earth's cone-shaped, umbral shadow, better shielding it from the red sunlight that refracts through our planet's atmosphere.

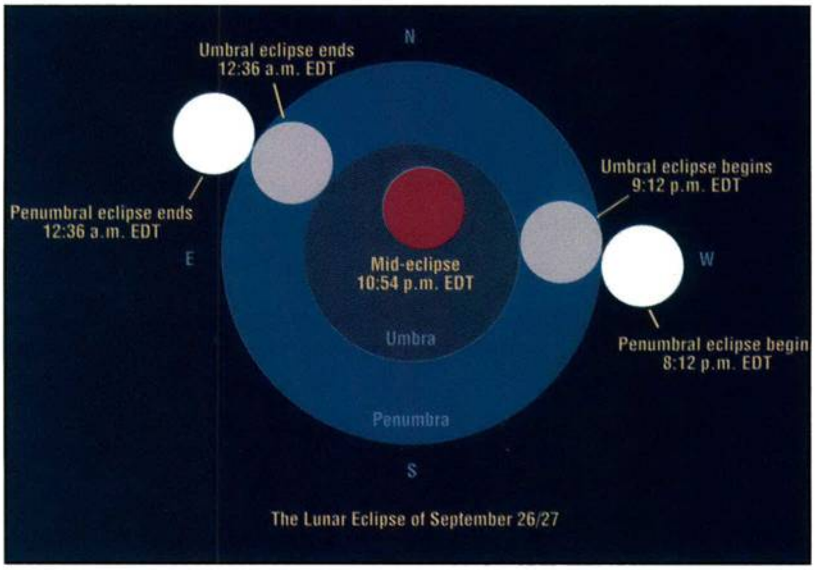
The second factor is more of a wild card and depends upon the clarity of Earth's atmosphere. If there's a volcanic eruption some time during 1996, it could contribute to a darker, less colorful total eclipse.

Regardless of what colors you'll see, there are other, more subtle sights worth noting. One is 0.5-magnitude Saturn, just over 2° to the south of the Moon. Coincidentally, it comes to opposition the same evening as the eclipse.

Another involves a 6.2-magnitude star, which gets covered during totality for those who live west of the Rockies. People along the United States-Canada border might even witness a grazing occultation, where the star's light winks in and out of the Moon's north polar valleys.

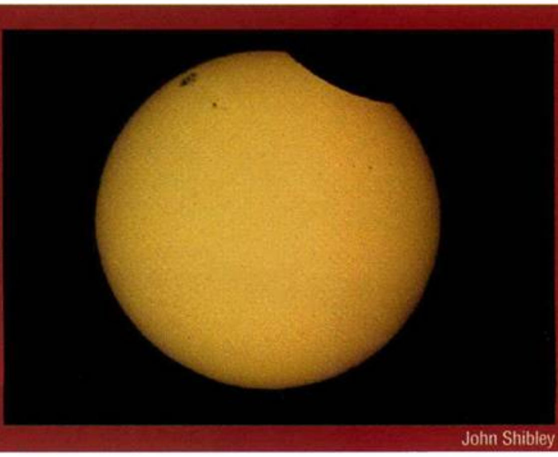
For the die-hard deep-sky observers there are multiple target galaxies arrayed nearby, including the 14th-magnitude spiral galaxy NGC 78 in Pisces, which lies some 53' southeast of the Moon.

The eclipse also holds opportunity for the photographer. If you piggyback a camera loaded with ASA 200 film on top of a telescope that tracks the sky, shoot a 15-minute exposure of the Moon and its environs using a lens set to f/5.6. Try framing the Moon and Saturn in a telephoto's field of view. ASTRONOMY magazine would welcome your photo submission.



The Lunar Eclipse of September 26/27

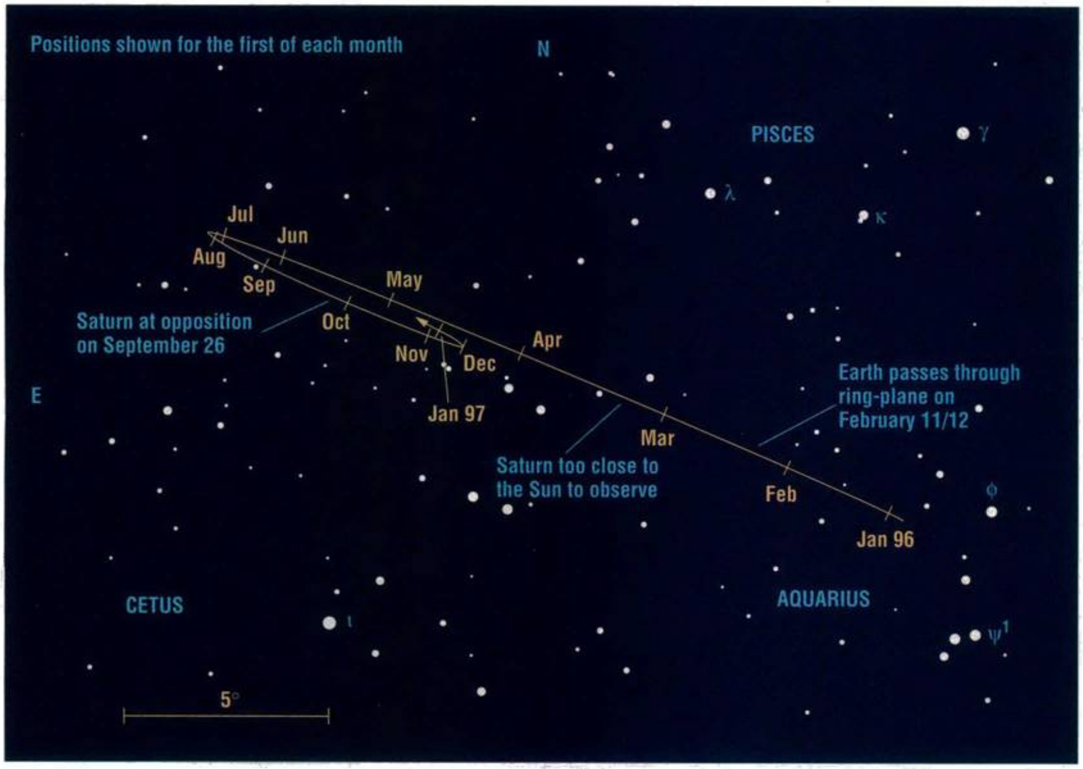
OBSERVERS IN NORTHERN Maine see our Moon take a bite out of the Sun during a partial solar eclipse on the morning of October 12. At best, they will see less than 3 percent of the Sun covered. Europeans, with their better view, should see close to 30 percent coverage. Partiality begins at sunrise over the Canadian Prairies and arctic and continues east across the North Atlantic, ending at sunset in the Middle East north to an area slightly east of the Urals.


John Shibley

The Ringed Planet Is Back

October

S	M	T	W	T	F	S
		1	2	3	◑	5
6	7	8	9	10	11	●
13	14	15	16	17	18	◐
20	21	22	23	24	25	○
27	28	29	30	31		


Positions shown for the first of each month
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Jan 97
Mar
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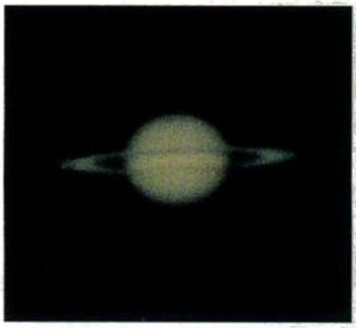
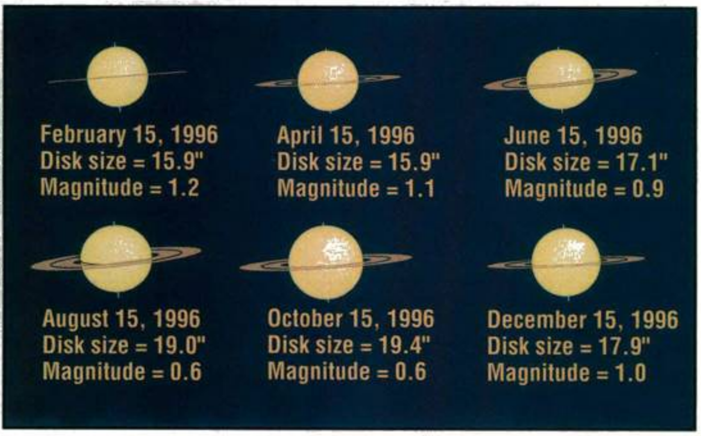
Jan 96
Saturn at opposition on September 26
Earth passes through ring-plane on February 11/12
Saturn too close to the Sun to observe
5°


Jean Dragesco


February 15, 1996
Disk size = 15.9"
Magnitude = 1.2

April 15, 1996
Disk size = 15.9"
Magnitude = 1.1

June 15, 1996
Disk size = 17.1"
Magnitude = 0.9

August 15, 1996
Disk size = 19.0"
Magnitude = 0.6

October 15, 1996
Disk size = 19.4"
Magnitude = 0.6

December 15, 1996
Disk size = 17.9"
Magnitude = 1.0

Lovers of beauty in the night sky will rejoice at the return of Saturn in all its glory. Throughout 1995, the ringed planet appeared as a ghost of its normal self, with rings that were at times invisible and at other times just a thin sliver extending along the planet's equator. The disappearing rings were brought to us by solar system geometry, which placed Earth very near the plane of the rings for most of last year.

Things aren't too different at the start of 1996, when Saturn lies low in the western sky after sunset. Earth then lies north and the Sun south of the rings, so we see their unilluminated face. If the rings were solid, they would be invisible at this time. However some sunlight filters through the rings, particularly the more tenuous parts. Observers with small scopes may not see them at all, but telescopes with 12 inches or more of aperture should reveal the ghostly, backlit rings.

Earth passes through the ring-plane for a third and final time on February 11/12, after which both the Sun and Earth lie on the south side of the rings for the first time since 1980. Unfortunately, Saturn then is closing in on solar conjunction, when it passes behind the Sun as seen from Earth, so it appears very low in the western twilight sky.

Saturn reappears in the morning sky in early April, with its resplendent rings once again shining brightly. The rings continue to open into July, when they are tipped 6° to our line of sight. By the time the planet reaches opposition on September 26 and then moves into the evening sky for a fine October appearance, the rings tilt a still respectable 4° and span 44". The planet then glows at around magnitude 0.5, by far the brightest point of light in the star-poor constellation of Pisces.

Day	Time (EDT, before Oct. 27)
1	**6 p.m.** **The Moon passes 0.8° north of Aldebaran**
3	**2 a.m.** **Mercury is at greatest western elongation (18°, morning)** **8 p.m.** **Venus passes 0.2° south of Regulus (morning)**
4	**8 p.m.** **Asteroid Juno is at opposition**
7	**11 a.m.** The Moon passes 6° south of Mars
8	**Midnight** **The Moon passes 4° south of Venus**
12	**10 a.m.** **Partial solar eclipse**
18	**Noon** The Moon passes 6° north of Jupiter
19	**1 p.m.** The Moon passes 5° north of Neptune **11 p.m.** The Moon passes 6° north of Uranus
21	**Orionid meteor shower peaks (First Quarter Moon)**
24	**6 a.m.** The Moon passes 3° north of Saturn
27	**2 a.m.** Daylight saving time ends
28	**11 p.m.** **Mars passes 1.2° north of Regulus (morning)**
29	**3 a.m.** **The Moon passes 0.9° north of Aldebaran**

November

S	M	T	W	T	F	S
					1	2
◑	4	5	6	7	8	9
●	11	12	13	14	15	16
◐	18	19	20	21	22	23
○	25	26	27	28	29	30

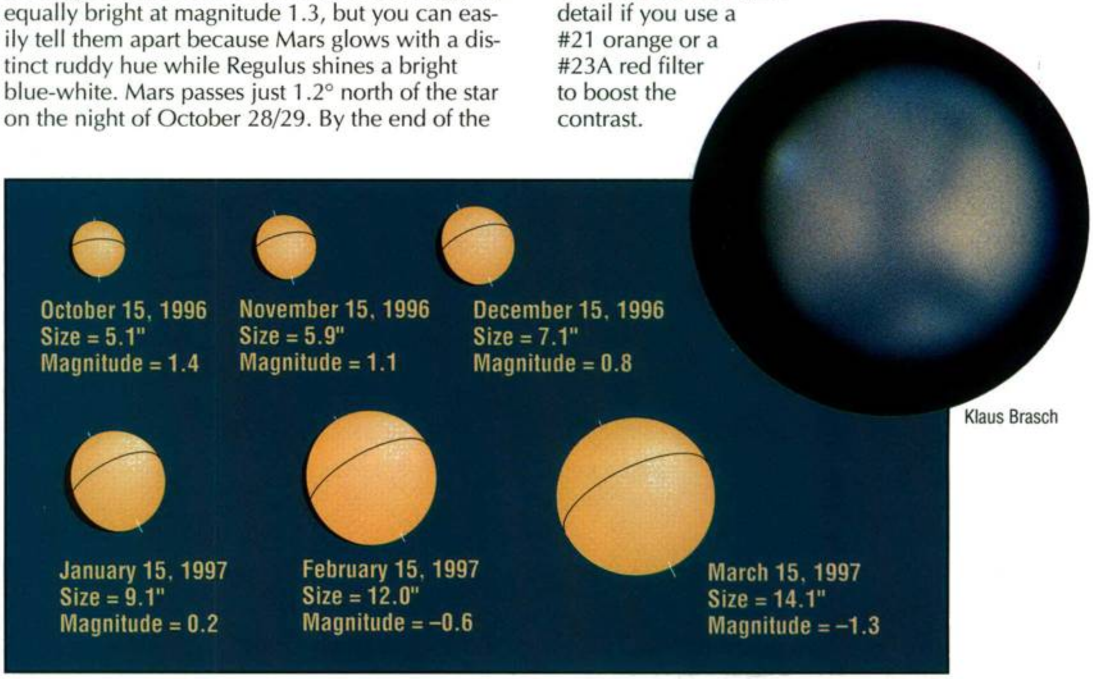
Day	Time (EST)
1	**7 p.m.** Mercury is in superior conjunction
5	**3 a.m.** The Moon passes 5° south of Mars
8	**5 a.m.** **The Moon passes 1.4° south of Venus**
14	**Midnight** **The Moon passes 5° north of Jupiter**
15	**6 p.m.** The Moon passes 4° north of Neptune
16	**4 a.m.** The Moon passes 5° north of Uranus **1 p.m.** Venus passes 4° north of Spica (morning)
17	**Leonid meteor shower peaks (First Quarter Moon)**
20	**10 a.m.** The Moon passes 3° north of Saturn **Noon** Mercury passes 3° north of Antares (evening)
24	**7 p.m.** Pluto is in conjunction with the Sun
25	**Noon** **The Moon passes 0.9° north of Aldebaran**

Get Ready for the Red Planet

Approximately every two years, Mars comes close to Earth, returning to prominence and appearing at its best through a telescope. The next of these biennial apparitions starts as 1996 winds to a close, so now's a good time to become familiar with the Red Planet.

During the final three months of 1996, Mars makes a beeline through the bright constellation Leo the Lion, which lies high in the south as morning twilight commences. Watch in particular during the last week of October and the first week of November, when Mars passes near the bright star Regulus, the heart of the lion. The two appear equally bright at magnitude 1.3, but you can easily tell them apart because Mars glows with a distinct ruddy hue while Regulus shines a bright blue-white. Mars passes just 1.2° north of the star on the night of October 28/29. By the end of the year, the planet moves into Virgo, where it remains through its opposition in mid-March 1997.

A good rule of thumb is that detail on the surface of Mars becomes easier to see when the planet appears at least 8" across, a threshold the planet reaches on December 31. But before then you should still be able to make out the largest dark markings and the bright white polar caps (the northern one now tilts in our direction). Experienced Mars observers will tell you the best way to glean detail on the Red Planet during an observing season is to get accustomed to it beforehand. You can also see more detail if you use a #21 orange or a #23A red filter to boost the contrast.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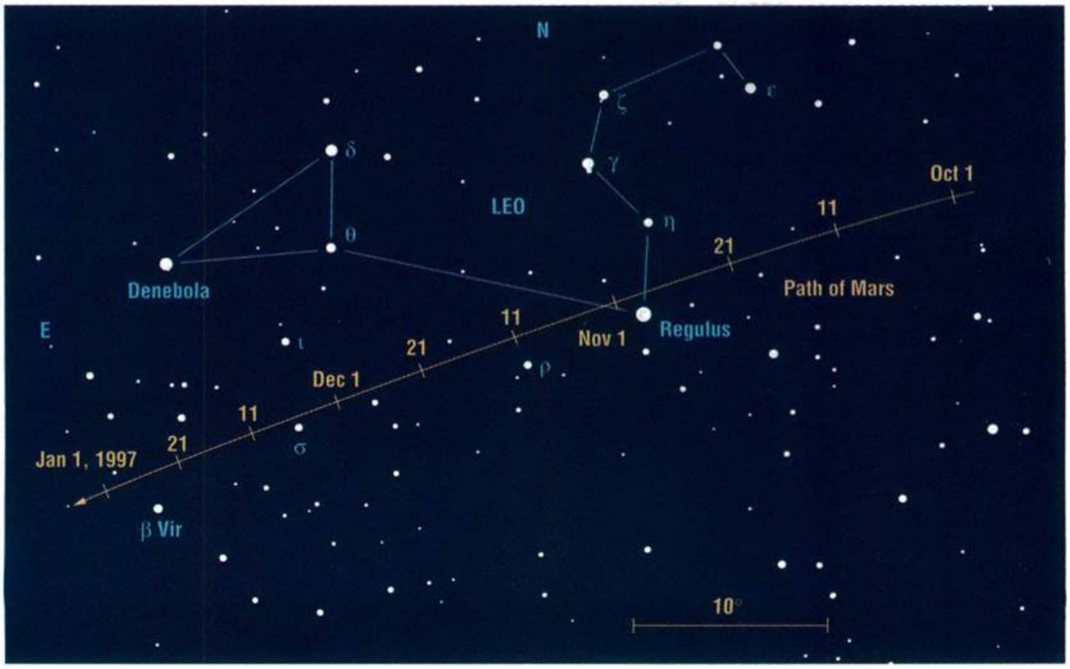
Magnitude = 1.4
November 15, 1996
Size = 5.9"
Magnitude = 1.1
December 15, 1996
Size = 7.1"
Magnitude = 0.8
January 15, 1997
Size = 9.1"
Magnitude = 0.2
February 15, 1997
Size = 12.0"
Magnitude = –0.6
March 15, 1997
Size = 14.1"
Magnitude = –1.3

Klaus Brasch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Path of Mars
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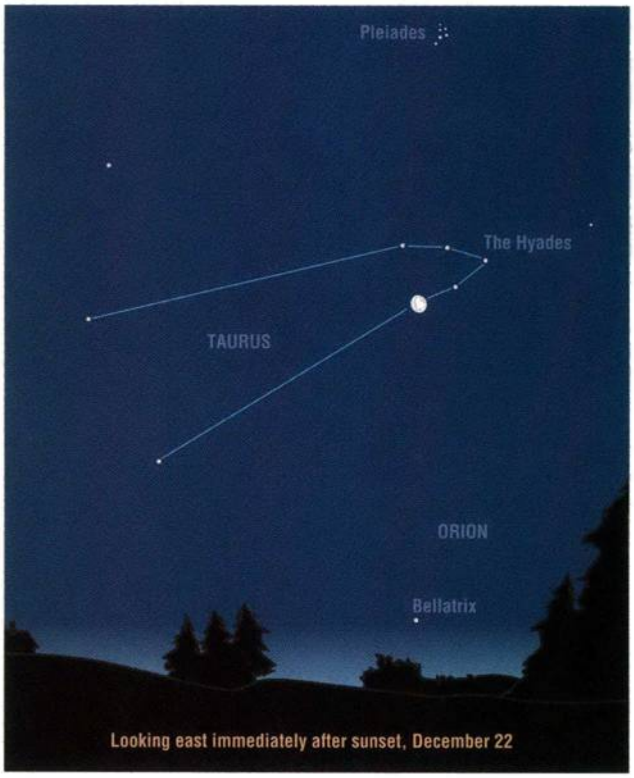
Moon in a Bull's Eye



Looking east immediately after sunset, December 22

Look east shortly after sunset on any crisp December evening and you're liable to see Taurus the Bull charging along the horizon replete with a gleaming red eye, the star Aldebaran. But even the mythological might of Taurus can't fend off a marauding gibbous Moon on the evening of December 22.

As the constellation emerges from dusk that night, our Moon covers, or occults, Aldebaran for observers in Canada. The rest of North America will see the Moon just miss the star. For those living near the Great Lakes, Aldebaran skirts the Moon's southern edge, and in some places undergoes a grazing occultation. Regardless of where you live, Taurus seems to gain a clarion eye of white in the form of a 12-day-old Moon.

If you've never witnessed a grazing occultation, it's quite a sight to see. For several minutes, the Moon approaches a star until the two barely appear to touch each other. Then in the blink of an eye, the star winks out of sight and then back in as the Moon's mountains and valleys alternately cover and reveal the star's light.

Early telescopic observers used this phenomenon to deduce the Moon's lack of an atmosphere; otherwise the star's brightness would fade slowly as it passed through air near the Moon's surface.

George Corti

A GEMINID METEOR STREAKS through Canis Major in this 30-second exposure. Between 50 and 80 meteors an hour will stream from a point near Gemini's Castor on the night of December 13/14. Geminids are bright and white, but leave few trails. This year, the waxing crescent Moon sets well before peak predawn viewing hours.

Today some astronomers still use lunar occultations to hone their understanding of the Moon's movement around Earth. By scrutinizing how a star winks out, they have even discovered double stars not resolvable in even the largest telescopes.

For skywatchers, though, the pleasure comes from watching our Moon move in its 2,200-mile-an-hour orbit to block the light of a star that's been traveling toward Earth for dozens of years. In Aldebaran's case, the light's been traveling for nearly 70 years. By contrast, our Moon is a mere 1.3 light-seconds away.

Because the night sky is full of stars, the Moon frequently passes in front of one of them. Occultations of fainter stars are best seen before First Quarter and after Last Quarter, when the Moon's glare isn't as overpowering. For a week either side of Full Moon, only brighter stars, those about as bright as Aldebaran, remain visible in the Moon's glare before being occulted.

For more information about occultations that can be seen in your area, write the International Occultation Timing Association (IOTA), 2760 SW Jewell Avenue, Topeka, KS 66611-1614, or contact them through e-mail at **570-0611@mcimail.com**.

December

S	M	T	W	T	F	S
1	2	◑	4	5	6	7
8	9	●	11	12	13	14
15	16	◐	18	19	20	21
22	23	○	25	26	27	28
29	30	31				

Day Time (EST)

3 **4 p.m.**
The Moon passes 4° south of Mars

8 **8 a.m.**
The Moon passes 2° north of Venus

9 **Midnight**
Asteroid Pallas is in conjunction with the Sun

11 **Midnight**
The Moon passes 7° north of Mercury

12 **6 p.m.**
The Moon passes 5° north of Jupiter

13 **2 a.m.**
The Moon passes 4° north of Neptune
1 p.m.
The Moon passes 5° north of Uranus
Geminid meteor shower peaks (New Moon)

15 **2 p.m.**
Mercury is at greatest eastern elongation (20°, evening)

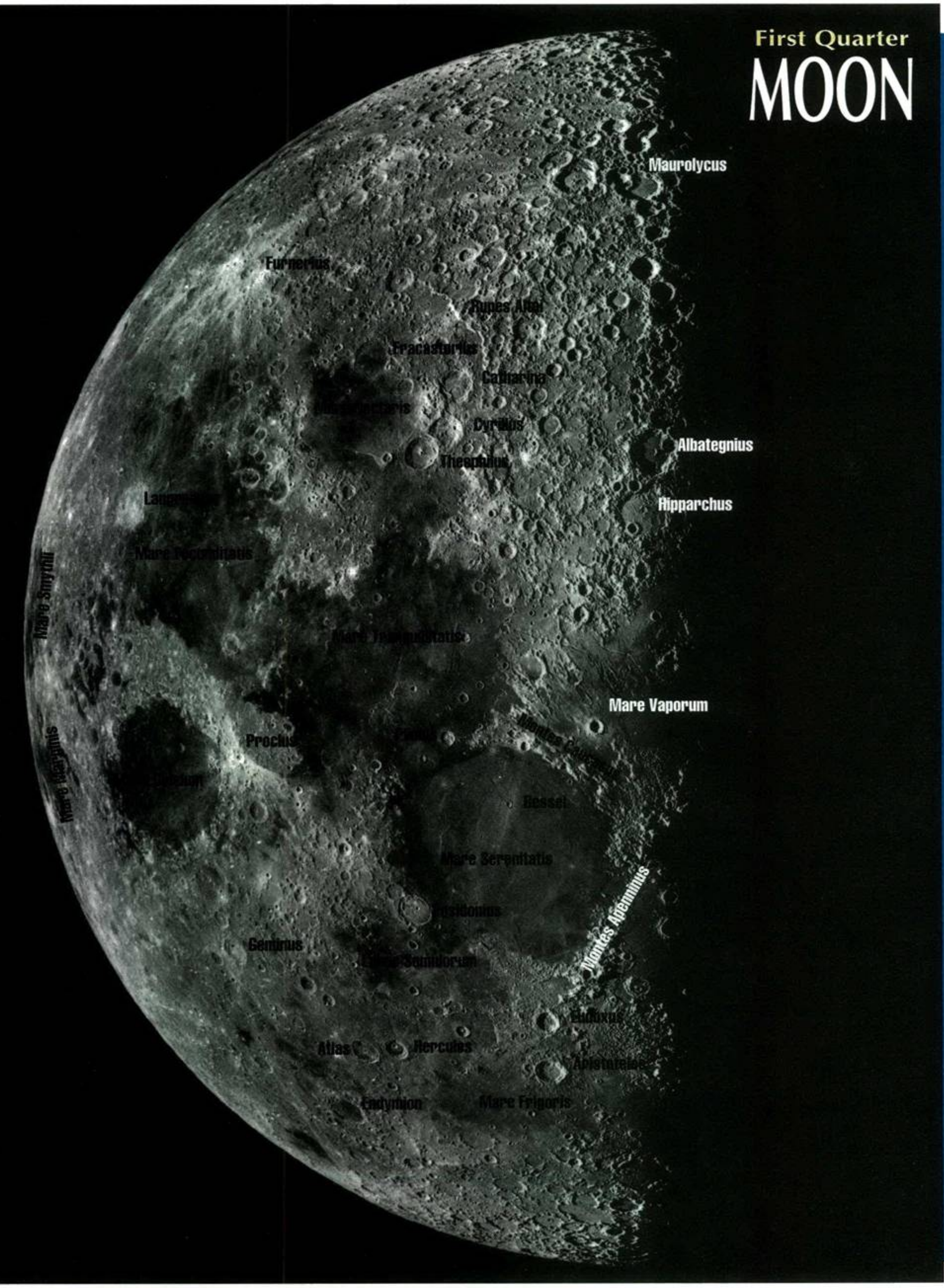
17 **3 p.m.**
The Moon passes 3° north of Saturn

21 **9 a.m.**
Solstice (northern winter/southern summer begins)

22 **7 p.m.**
The Moon passes 0.9° north of Aldebaran

24 **2 a.m.**
Venus passes 6° north of Antares (morning)

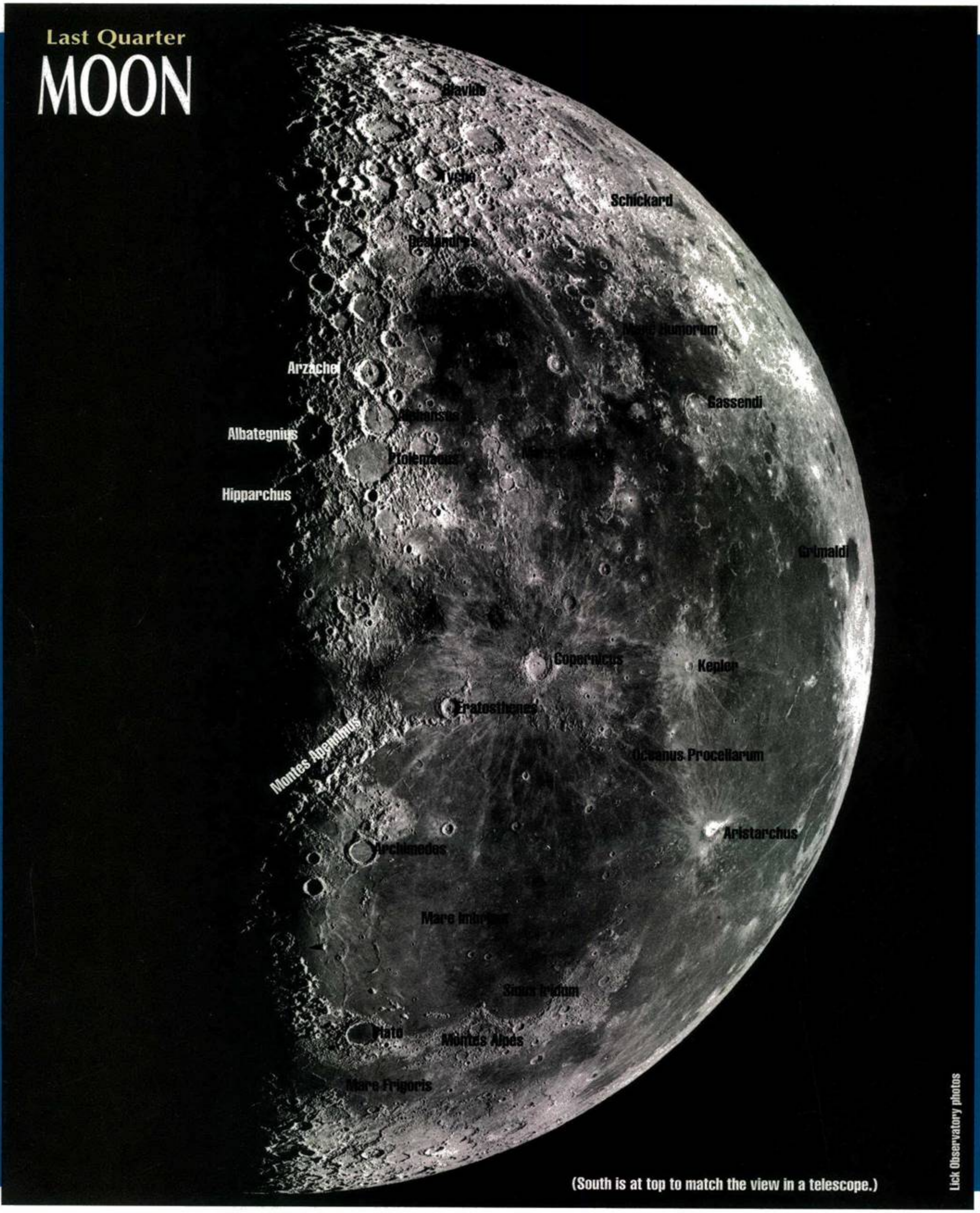
Exploring the Moon


First Quarter
MOON
Maurolycus
Furnerius
Rupes Altai
Fracastorius
Catharina
Mare Nectaris
Cyrillus
Theophilus
Albategnius
Hipparchus
Langrenus
Mare Fecunditatis
Mare Smythii
Mare Tranquillitatis
Mare Vaporum
Proclus
Plinius
Montes Caucasus
Mare Marginis
Mare Crisium
Bessel
Mare Serenitatis
Montes Apenninus
Posidonius
Geminus
Lacus Somniorum
Eudoxus
Aristoteles
Atlas
Hercules
Endymion
Mare Frigoris

Everyone's first telescopic target is the Moon, and it's easy to see why. For sheer drama, it's hard to beat cruising over the lunar surface with a telescope. No matter what size instrument you use, you get an eye-filling view of craters, mountains, rilles, and rays — mute testimony to the Moon's 4.5 billion years of geological violence.

While Full Moon has its attractions, the best time to explore the Moon by telescope is when sunlight strikes the surface at a shallower angle. This throws its features into starkest relief. For a

Last Quarter
MOON


Clavius
Tycho
Schickard
Deslandres
Mare Humorum
Arzachel
Alphonsus
Gassendi
Albategnius
Ptolemaeus
Hipparchus
Grimaldi
Copernicus
Kepler
Eratosthenes
Montes Apenninus
Oceanus Procellarum
Aristarchus
Archimedes
Mare Imbrium
Sinus Iridum
Plato
Montes Alpes
Mare Frigoris

(South is at top to match the view in a telescope.)

Lick Observatory photos

few days before and after First and Last Quarter Moon, lunar adventuring is at its finest. Start with the lowest power eyepiece your telescope has and slowly increase magnification as one feature or another draws your eye. If the view becomes unsteady, lower the magnifcation until disturbances in Earth's atmosphere no longer interfere and the view sharpens.

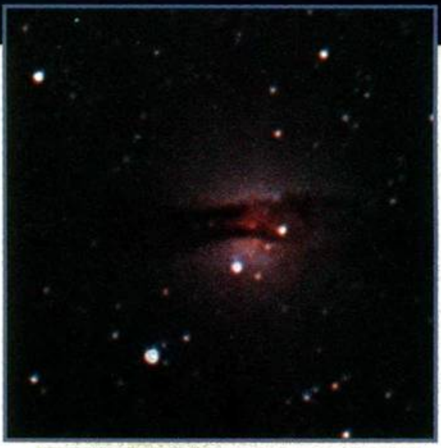
No one can say when the next human will visit the Moon, but every backyard telescope is a kind of spaceship that can take us there in our imaginations.

The Springtime Stars

Walk outside in late evening under a dark spring sky to discover the most recognizable sky figure, the Big Dipper, high in the sky. The brightest part of the constellation Ursa Major the Bear, several of the Big Dipper's stars are members of the closest association of stars astronomers know. In other words, the stars are gravitationally bound and are traveling together as they orbit the center of our Galaxy. These stars are a mere 70 light-years away, so their light actually left the stars some 70 years ago. As these stars continue around the Galaxy, they will eventually disperse, so that millions of years from now the Big Dipper figure will no longer grace our sky.

A pair of binoculars reveals other, more distant denizens of the spring sky. The Whirlpool Galaxy (M51) in Canes Venatici may be found south of the Big Dipper's handle. Follow the handle's arc to find the bright star Arcturus in Bootes the Herdsman, and continue southward to Spica, in the constellation Virgo the Virgin. The edge-on galaxy M104 in Virgo appears in small telescopes as a saucer-shaped apparition. Between Virgo and Ursa Major, and slightly westward, lies Leo the Lion, home of the trio of galaxies M65, M66, and NGC 3628.

Other treats may be found by binocular or small-telescope observers. Cancer the Crab holds one of the sky's most brilliant star clusters, the Beehive (M44), visible to the eye alone on dark nights. In the southern constellation Centaurus the Centaur, look for the big, oval galaxy Centaurus A (NGC 5128) with its broad dust lane. Many more galaxies and star groups highlight spring's evening show.



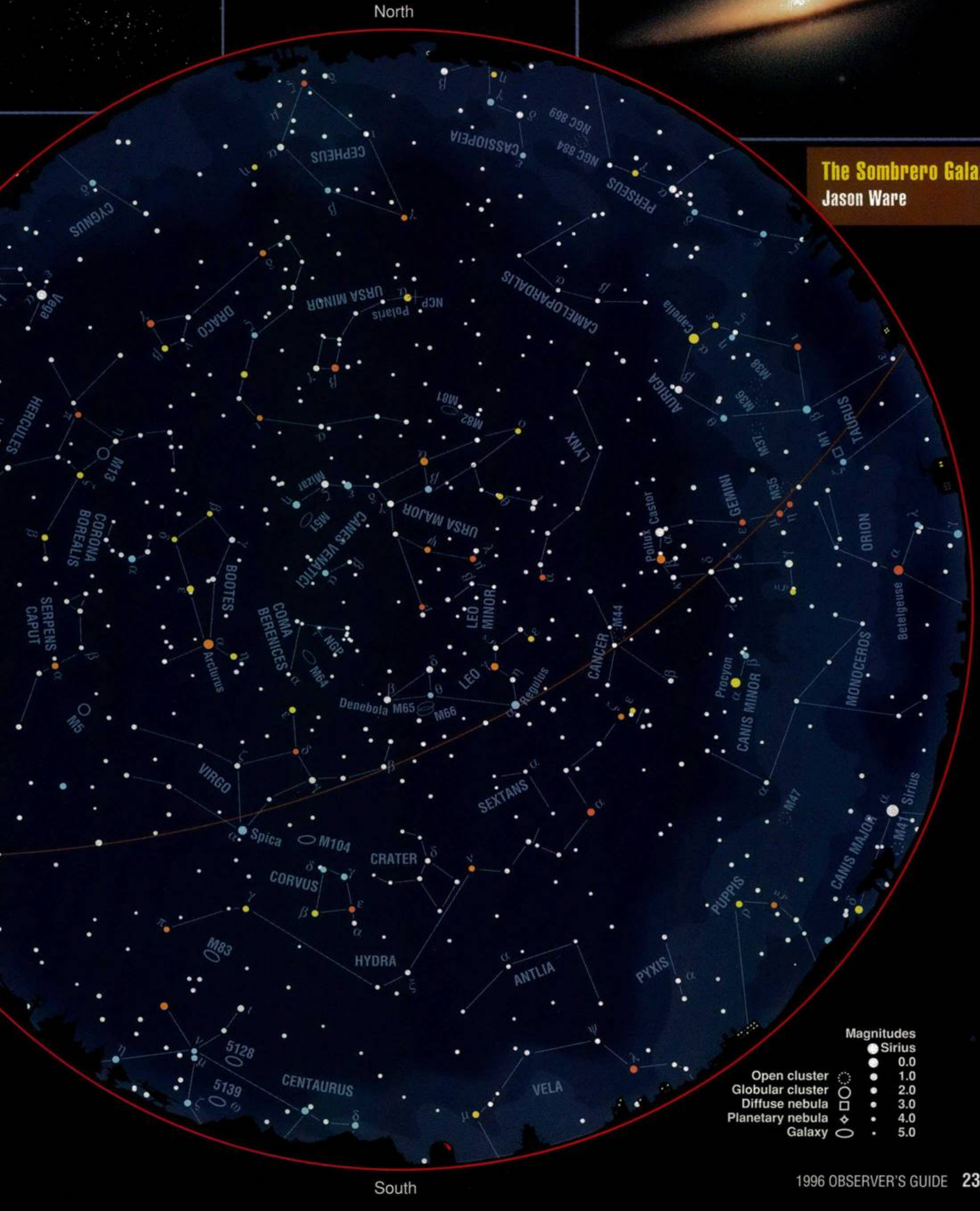
Peculiar galaxy Centaurus A
Chris Schur

Galaxies M65, M66, and NGC 3628
Peter Ledlie

The Whirlpool Galaxy
Bill Iburg

The Beehive Star Cluster
Ronald E. Royer

The Sombrero Galaxy
Jason Ware


North
South
West
CEPHEUS
CASSIOPEIA
NGC 869
NGC 884
PERSEUS
CYGNUS
Vega
DRACO
URSA MINOR
NCP
Polaris
CAMELOPARDALIS
Capella
AURIGA
M38
M36
M37
M81
M82
HERCULES
M13
LYNX
M1
TAURUS
Mizar
M51
CANES VENATICI
URSA MAJOR
GEMINI
M35
Castor
Pollux
ORION
Betelgeuse
CORONA BOREALIS
BOOTES
COMA BERENICES
NGP
LEO MINOR
M44
CANCER
SERPENS CAPUT
Arcturus
M64
LEO
Regulus
Procyon
CANIS MINOR
MONOCEROS
M5
Denebola
M65
M66
VIRGO
SEXTANS
M47
Sirius
M41
CANIS MAJOR
Spica
M104
CRATER
CORVUS
PUPPIS
M83
HYDRA
ANTLIA
PYXIS
5128
5139
CENTAURUS
VELA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Summer's Gleaming Milky Way

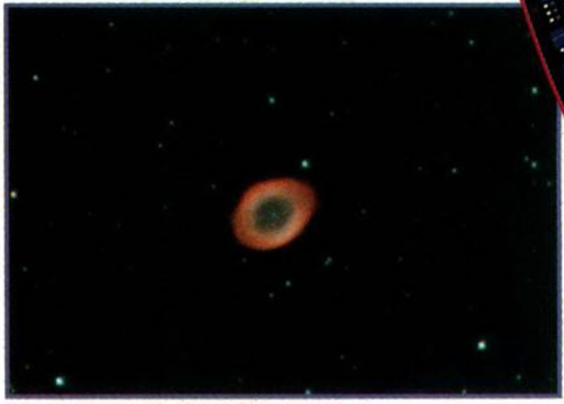
There's no sky like the summer sky. Overhead, the Summer Triangle casts its light onto the landscape below. The brightest of the three lies farthest west, white Vega in the constellation Lyra the Harp. East of this beacon lies Deneb, a white star that marks the tail of Cygnus the Swan. The southern apex of the triangle is Altair, the bright eye of Aquila the Eagle. Soak in the light from these three prominent stars and slowly begin to perceive the faint, wispy band of light arching overhead, the summer Milky Way.

This ethereal glow comes from the unresolved light of countless distant stars that make up our Galaxy's disk. Dozens of deep-sky treats are embedded along and around this band of light, residents of the Galaxy that reveal themselves in binoculars or a small telescope on any clear, dark summer night. High overhead, near Lyra, lies Hercules, home of the Hercules Cluster (M13), a globular star cluster. This huge sphere of more than a million old, yellow stars hovers high in the halo of our Galaxy, away from the younger disk. Glimpse it with a pair of binoculars. Nearby in Lyra is the Ring Nebula (M57), visible in small telescopes as a smoke-ring of glowing light. In actuality, it is the remains of a dying star.

Young stars and the glowing clouds from which they are forming pepper the Galaxy's band farther south, in Sagittarius and Serpens. The Lagoon Nebula (M8) and Omega Nebula (M17) are visible as tiny glows to the eye alone and may be viewed comfortably with binoculars. Another globular cluster, M22, similar in size and brightness to the one in Hercules, stands out in northern Sagittarius.

The Lagoon Nebula
Bob Gleich

Globular star cluster M22
Kim Zussman

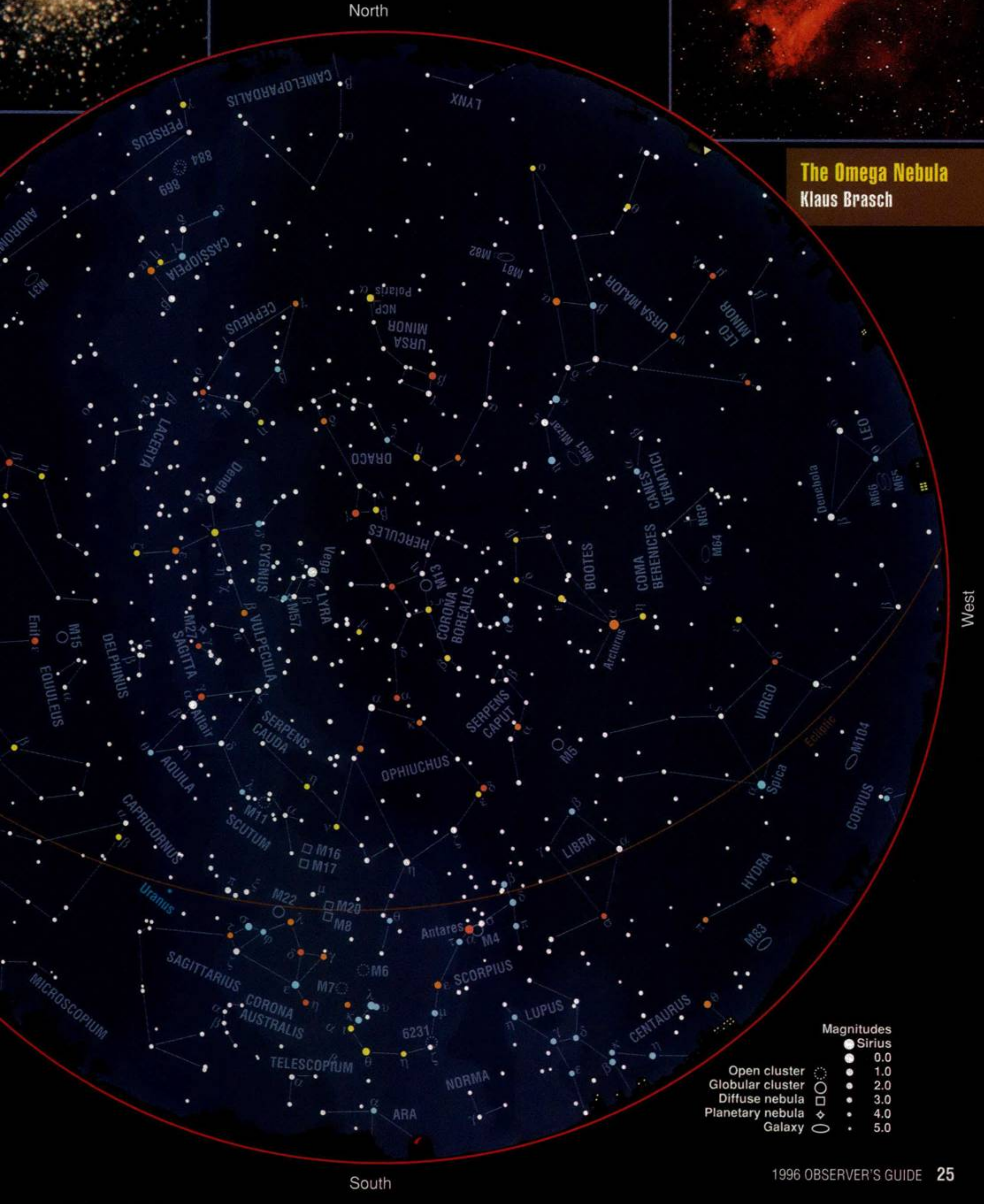


The Ring Nebula
Jack Newton

EGASUS
PISCES

Globular star cluster M13
Jason Ware

The Omega Nebula
Klaus Brasch


North
South
West
CAMELOPARDALIS
LYNX
PERSEUS
869
884
ANDROM
M31
CASSIOPEIA
CEPHEUS
Polaris
NCP
URSA MINOR
M82
M81
URSA MAJOR
LEO MINOR
DRACO
LACERTA
Deneb
CYGNUS
Vega
LYRA
M57
HERCULES
M13
CORONA BOREALIS
M51
Mizar
CANES VENATICI
NGP
M64
COMA BERENICES
BOOTES
Arcturus
LEO
Denebola
M66
M65
VULPECULA
M27
SAGITTA
DELPHINUS
M15
Enif
EQUULEUS
Altair
AQUILA
SERPENS CAUDA
SERPENS CAPUT
M5
OPHIUCHUS
VIRGO
Ecliptic
M104
Spica
CORVUS
M11
SCUTUM
CAPRICORNUS
M16
M17
LIBRA
HYDRA
Uranus
M22
M20
M8
Antares
M4
M83
M6
M7
SCORPIUS
SAGITTARIUS
MICROSCOPIUM
CORONA AUSTRALIS
LUPUS
CENTAURUS
6231
TELESCOPIUM
NORMA
ARA
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Crisp, Cool Autumn Galaxies

On autumn evenings the sky takes on a less busy appearance relative to the bright glows of the summer Milky Way. Now a stark area away from the light of our Galaxy rolls around into view and a few galaxies far beyond our own come into play. The prominent W-shaped star group overhead represents the constellation Cassiopeia the Queen. Below Cassiopeia toward the southern horizon lies a square of four bright stars. The Great Square marks the body of Pegasus the Flying Horse.

West of Pegasus, between Cygnus and Aquila, lies the tiny constellation Vulpecula the Fox. Binoculars trained toward this area will show the small glow called the Dumbbell Nebula (M27), the faintly glowing remnant of a once healthy star. The southwestern corner of the Great Square features a string of bright stars that extends toward Aquila. Near the end of this string is an outstanding globular star cluster, M15. Binoculars reveal a fuzzy "star" that represents the hazy light of hundreds of thousands of individual suns.

Traveling to the other side of Pegasus brings Andromeda into focus, site of the Andromeda Galaxy (M31). This soft, oval glow is visible to the naked eye: in fact, it's the most distant object unaided human eyes can see, at 2.2 million light-years. Southeast of the Andromeda Galaxy in the tiny constellation Triangulum is another galaxy, M33, which requires binoculars to be seen even on a dark night. Moving far to the south brings into view another galaxy visible in binoculars, NGC 253 in the southern constellation Sculptor. This galaxy is similar in overall type and brightness to our Milky Way, such that it represents what our Galaxy may look like from the outside.

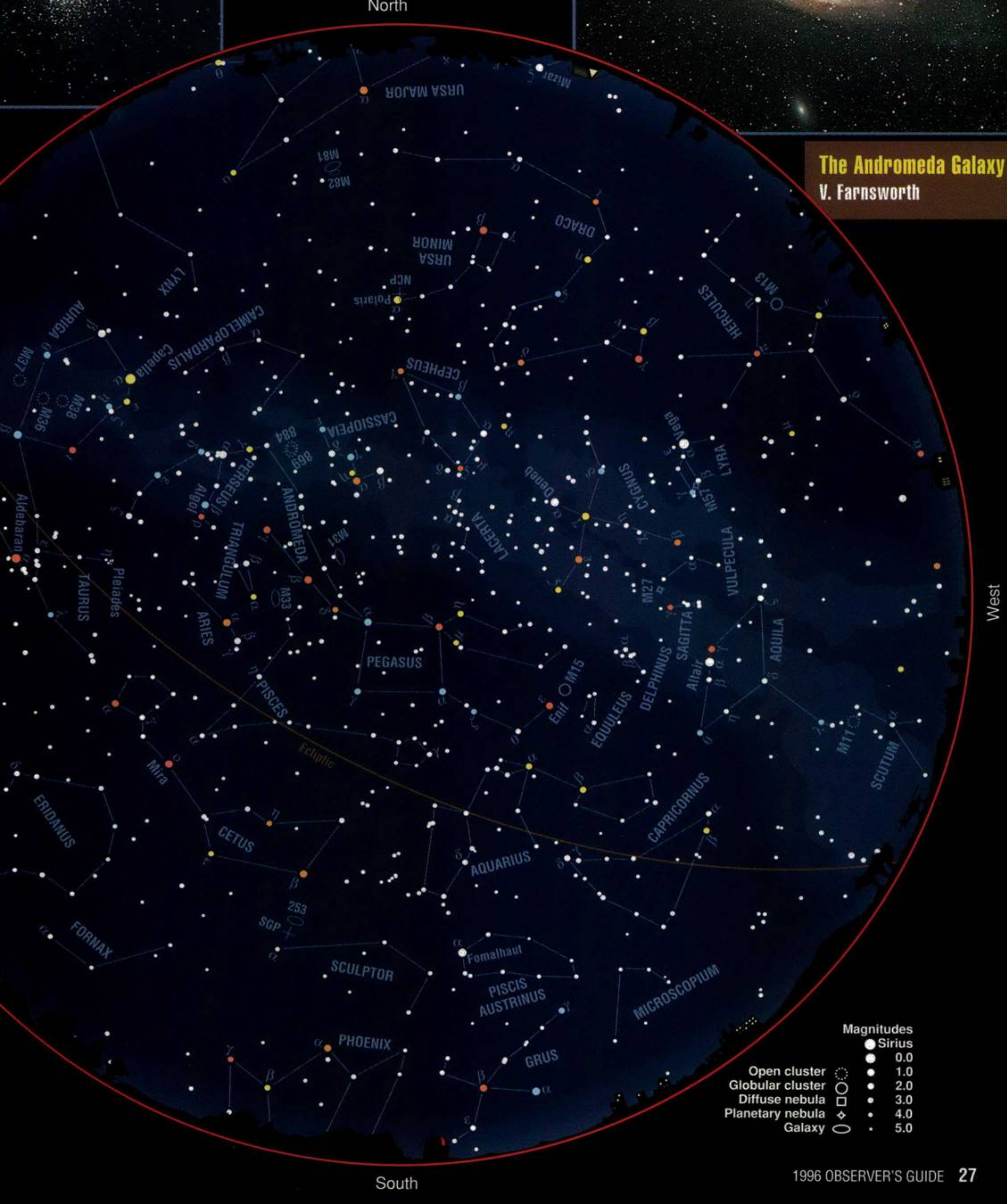
Spiral galaxy M33
Ronald E. Royer

The Dumbbell Nebula
Jerry Lodriguss

Spiral galaxy NGC 253
Joe Liddell

Globular star cluster M15
James R. Foster

The Andromeda Galaxy
V. Farnsworth


North
West
South
URSA MAJOR
Mizar
M81
M82
DRACO
URSA MINOR
NCP
Polaris
LYNX
AURIGA
CAMELOPARDALIS
Capella
M37
M36
M38
HERCULES
M13
CEPHEUS
CASSIOPEIA
884
869
Vega
LYRA
M57
CYGNUS
Deneb
PERSEUS
Algol
ANDROMEDA
LACERTA
M31
TRIANGULUM
M33
Aldebaran
Pleiades
TAURUS
ARIES
VULPECULA
M27
SAGITTA
AQUILA
Altair
DELPHINUS
EQUULEUS
M15
Enif
PEGASUS
PISCES
Ecliptic
Mira
M11
SCUTUM
CAPRICORNUS
ERIDANUS
CETUS
AQUARIUS
SGP
253
FORNAX
SCULPTOR
Fomalhaut
PISCIS AUSTRINUS
MICROSCOPIUM
PHOENIX
GRUS
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

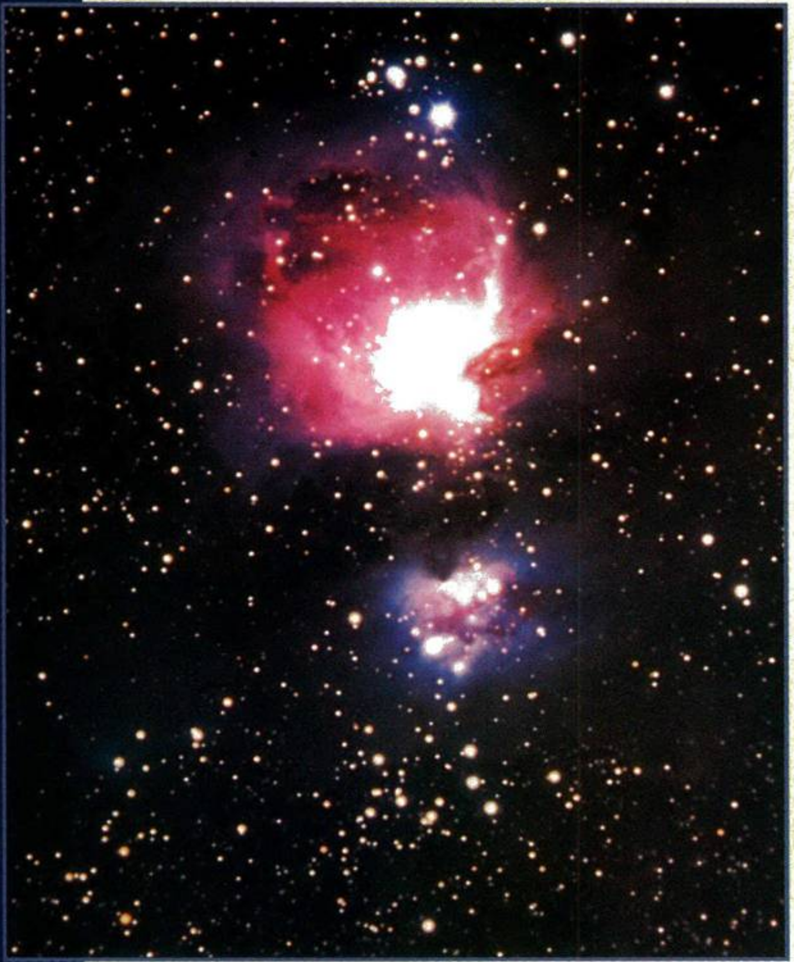
The Sparkly Winter Sky

Chilled and often crystal-clear, winter's evening sky brings into view another section of Milky Way glow, creating a star-studded show of tiny star clusters and glowing clouds. The keystone of the show is the constellation Orion the Hunter, which features a distinctive pattern of three stars in a row standing over the southern horizon. This is Orion's belt. A short distance south of this row lies the most observed deep-sky object of all, the Orion Nebula (M42). This immense cloud of glowing gas is a star factory creating new suns from the recycled refuse of old, dead stars.

The bright star group Taurus the Bull, northwest of Orion, contains a smaller cloud of gas at the opposite end of a star's life. The Crab Nebula (M1) is the expanding shell of gas cast off by a supernova that exploded nearly a thousand years ago. The constellation also features bright open star clusters visible to the eye alone, the Hyades (a big, V-shaped group) and the sparkling Pleiades (M45), a smaller, dipper-shaped cluster of stars. Both offer fantastic areas for scanning with a pair of binoculars.

Southeast of Orion is the bright constellation Canis Major the Larger Dog, which contains the sky's brightest star, Sirius. A short distance south of Sirius is the big, pretty open cluster M41, visible to the naked eye but satisfying in binoculars. Another large open cluster lies high up, nearly straight overhead: the Double Cluster in Perseus (NGC 869 and NGC 884) offers two for the price of one, two sparkling groups of stars in a single binocular view.

East
M64
COMA BERENICES
VIRGO
CRATER



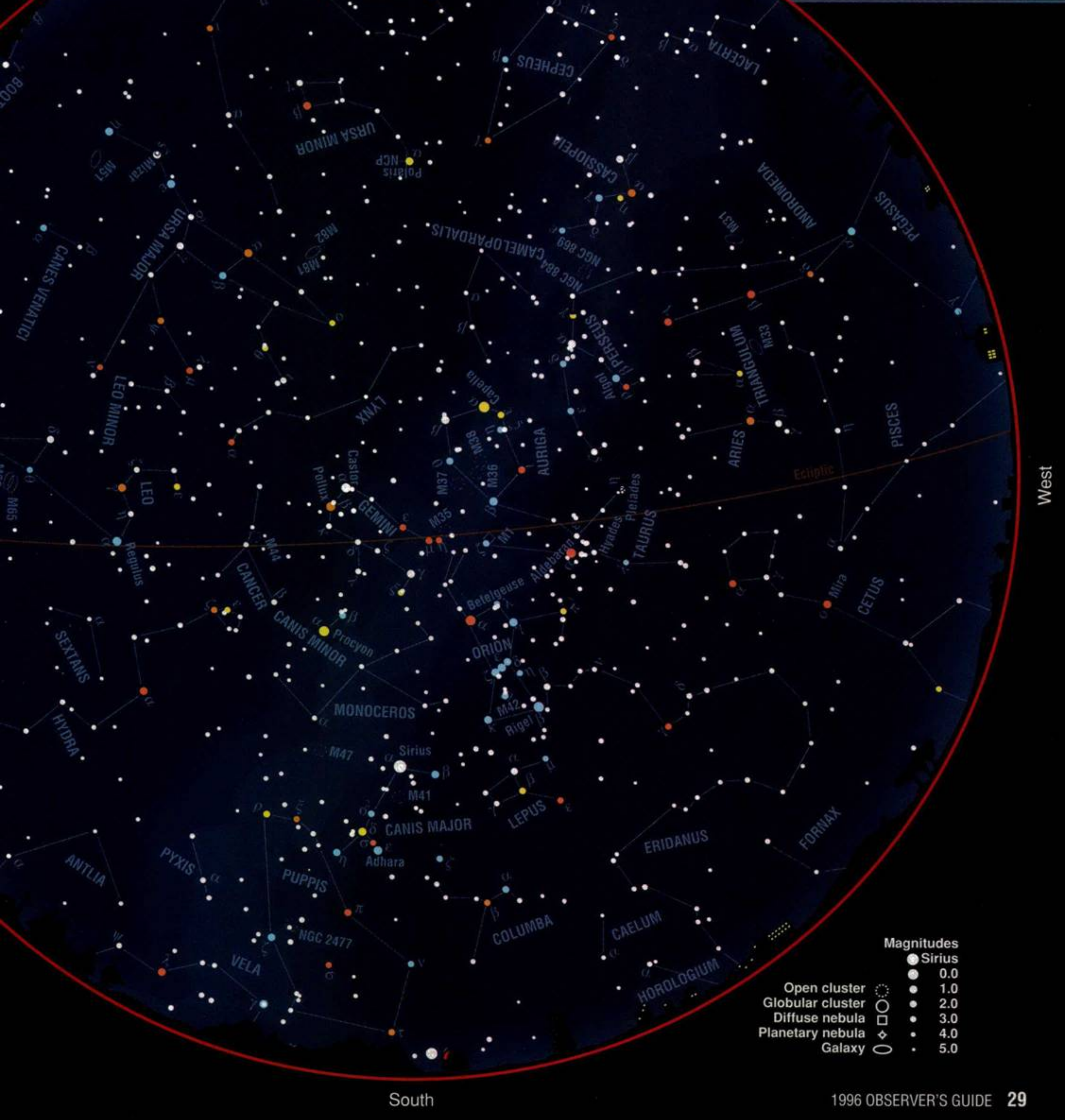
The Orion Nebula
Alberto Levy

Open star cluster M41
Paul Maley

The Pleiades
Jerry Lodriguss

The Crab Nebula
Bill and Sally Fletcher

The Double Cluster in Perseus
Michael Stecker


DRACO
CEPHEUS
LACERTA
URSA MINOR
Polaris
NCP
CASSIOPEIA
ANDROMEDA
PEGASUS
M57
Mizar
URSA MAJOR
CANES VENATICI
BOOTES
M82
M81
CAMELOPARDALIS
NGC 869
NGC 884
M31
PERSEUS
TRIANGULUM
M33
Algol
Capella
LYNX
LEO MINOR
AURIGA
ARIES
PISCES
M38
M36
M37
Castor
Pollux
GEMINI
M35
LEO
M65
Regulus
M44
M1
Pleiades
Hyades
TAURUS
Aldebaran
Ecliptic
West
CANCER
Betelgeuse
CETUS
Mira
CANIS MINOR
Procyon
SEXTANS
ORION
MONOCEROS
M42
Rigel
HYDRA
M47
Sirius
M41
LEPUS
CANIS MAJOR
Adhara
ERIDANUS
FORNAX
ANTLIA
PYXIS
PUPPIS
COLUMBA
CAELUM
NGC 2477
VELA
HOROLOGIUM
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Selecting Your First Telescope

Answering some common telescope questions makes purchasing your first scope easier.

by Alan Dyer

Larry Landolfi

It's a monster mall of telescopes out there. The shops, magazine ads, and mail order houses are filled with a maze of models and a befuddlement of brands. Apos, dobs, cats, computers — yikes! All you want is a good telescope that will provide clear, sharp views for not a lot of money.

Let's take a stroll through the mall and see what we can find. While we're at it, let's answer a few of the many questions firsttime buyers often ask.

1 What's the best telescope to buy?

It isn't any particular type or brand. The best telescope for you is the one you will use most often. Forget whether it's a refractor or reflector. Forget how many gadgets it has. Don't even worry about how much aperture it has.

The portability and convenience of a telescope are far more important than most first-time shoppers realize. What's the point of owning a scope if it's too big and bulky to use?

Select a telescope that is solidly-crafted but simple to use, with a minimum of "fiddly bits" that you'll soon tire of assembling and adjusting each night. Remember, you'll be using the telescope in the dark, in the cold, at odd hours of the night.

2 How much does it magnify?

Before we venture any farther down the mall, let's dispel one telescope myth. Contrary to what you might think, we're not looking for the most powerful telescope. In fact, a good rule of thumb is to avoid any telescope advertised primarily by how much magnification it provides. The "500x professional models" in the windows of camera stores are just plastic toys in disguise.

3 So what is more important than magnification?

In a word: aperture — the diameter of the lens or mirror that collects the light. The larger the aperture, the more light the telescope collects. Images in a 6-inch telescope, for example, appear four times brighter and twice as sharp as images in a 3-inch telescope. A 12-inch telescope provides the same jump in performance over a 6-inch.

Aperture is critical. But before eyeing that giant telescope, know that the best telescope is not necessarily the biggest one you can afford.

Let's be practical for a moment:

How big is the telescope? Will it fit into your car? Will it fit through your doorways? Down your stairs?

How heavy is it? Some scopes require you to lift 50 to 70 pounds waist high

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during assembly. How's your back?

How many pieces does the telescope break into? Lots of little pieces could be as much trouble as a few heavy ones. Do you need tools to put it together?

On most nights, you'll find that the telescope you use most often is one you can keep assembled and carry or wheel out to the backyard as a single unit.

4 How much do I have to spend?

For a good starter scope, expect to spend at least $300 for the basic telescope. But budget another $75 to $150 for required accessories: an extra eyepiece or two, perhaps a finderscope, and a set of star charts.

5 I'm buying a telescope for my child . . .

Don't skimp. A cheaply made telescope can do more to discourage an interest in astronomy than no telescope at all. Plastic, 500x department-store telescopes can show the Moon but little else well.

Achromatic Refractors

Manufacturer	Model	Aperture (in.)	f/ratio	Mount design	Drive	Slow motion	Setting circles	Finder	Focuser size (in.)	Average selling price
2.4-inch (60mm) Altazimuth Refractors										
Orion	Observer 60	2.4	11.6	Altazimuth	—	√	—	5x24	.965	$144
Meade	#227	2.4	11.7	Altazimuth	—	√	—	5x24	1.25	$199
Tasco	#302058	2.4	11.6	Altazimuth	—	√	—	5x24	.965	$229
Simmons	#6330	2.4	13.3	Altazimuth	—	—	—	5x24	.965	$250
Orion	TeleVista II	2.4	11.6	Altazimuth	—	√	—	5x24	1.25	$269
Parks	PRT-1	2.4	11.6	Altazimuth	—	—	—	5x24	1.25	$299
Simmons	#6340	2.4	11.6	Altazimuth	—	√	—	5x24	.965	$300
Swift	#862	2.4	11	Altazimuth	—	—	—	5x24	.965	$320
Parks	WF-60	2.4	7.6	—	—	—	—	6x30	1.25	$350
Swift	#863	2.4	13.3	Altazimuth	—	√	—	5x24	.965	$450
Parks	PRT-2	2.4	11.6	Altazimuth	—	√	—	10x	1.25	$499
Celestron	Firstscope 60	2.4	13.3	Altazimuth	—	√	—	5x24	1.25	call
Celestron	Firstscope 60-DX	2.4	13.3	Altazimuth	—	√	—	5x24	1.25	call
2.4-inch (60mm) Equatorial Refractors										
Meade	#285	2.4	15	German equatorial	opt.	√	√	6x30	1.25	$299
Tasco	#302851	2.4	15	German equatorial	—	√	√	5x24	.965	$321
Simmons	#6440	2.4	15	German equatorial	—	√	√	5x24	.965	$330
Edmund	#S31-611	2.4	8	Equatorial fork	—	—	—	5x24	1.25	$419
Parks	PRT-46	2.4	15.1	German equatorial	opt.	√	√	10x	1.25	$599
Swift	#859R	2.4	15	German equatorial	opt.	√	√	6x30	.965	$750
Unitron	#128	2.4	15	German equatorial	AC	√	√	6x24	1.25	$1,125
Celestron	Firstscope 60-EQ	2.4	13.3	German equatorial	—	√	√	6x24	1.25	call
Celestron	Firstscope 60-EQ-DX	2.4	13.3	German equatorial	—	√	√	6x24	1.25	call
3-inch (80mm to 90mm) Altazimuth Refractors										
Sky Designs/Instr.*	Omcon 128SE	3.1	12.5	Altazimuth	—	—	—	6x30	1.25	$400
Meade	#390	3.6	11	Altazimuth	—	√	—	6x30	1.25	$499
Unitron	#140	3.0	16	Altazimuth	—	√	—	6x24	1.25	$1,250
Celestron	Premium 80	3.1	11.4	Altazimuth	—	√	—	6x30	1.25	call
3-inch (80mm to 90mm) Equatorial Refractors										
Cosmos	93mm Refractor	3.7	9.7	German equatorial	opt.	√	√	6x30	1.25	$495
Orion	SkyView 90	3.5	11.1	German equatorial	opt.	√	√	6x30	1.25	$599
Meade	#395	3.6	11	German equatorial	opt.	√	√	6x30	1.25	$599
Sky Designs/Instr.*	Omcon 128D	3.1	12.5	German equatorial	DC	√	√	6x30	1.25	$600
Photon	PIC80LC	3.1	15	German equatorial	—	√	√	6x30	1.25	$650
Parks	PRT-813	3.1	11.2	German equatorial	opt.	√	√	6x30	1.25	$699
Sky Designs/Instr.*	Omcon 119D	3.6	10.8	German equatorial	DC	√	√	6x30	1.25	$700
Fraunhofer	3.1" Doublet	3.1	15	German equatorial	AC	√	√	6x30	1.25	$930
Photon	PIC80	3.1	15	German equatorial	DC	√	√	6x30	1.25	$1,625
Photon	PIC80F	3.1	15	German equatorial	DC	√	√	6x30	1.25	$1,950
Unitron	#142	3	16	German equatorial	AC	√	√	8x30	1.25	$1,950
4-inch and Larger Refractors										
Celestron	GP-C102ED	4	9	German equatorial	opt.	√	√	6x30	1.25	call
Celestron	GP-C102	4	9.8	German equatorial	opt.	√	√	6x30	1.25	call
Sky Designs	Omcon 1211T	4.1	12.4	German equatorial	opt.	√	√	6x30	2	call
Sky Instr.	Antares 1211	4.1	12.4	German equatorial	DC	√	√	8x50	2	$1,700
Unitron	#150	4	15	Altazimuth	—	√	—	10x42	1.25	$2,875
Photon	PIC100F	4	15	German equatorial	DC	√	√	7x50	1.25	$3,450
Unitron	#152	4	15	German equatorial	AC	—	√	10x42	1.25	$3,700
D & G	5" Achromat	5	12	opt.	—	—	—	8x50	2.7	$1,295
D & G	6" Achromat	6	12	opt.	—	—	—	8x50	2.7	$1,595
Fraunhofer	6" Doublet	6	15	opt.	—	—	—	8x50	2	$3,000
Photon	PIC125	5	15	German equatorial	DC	√	√	7x50	2	$5,300
Photon	PIC150	6	15	German equatorial	DC	√	√	7x50	2	$5,950

Also available: 8" and 10" achromatic refractors from D & G Optical; 5" and 6" achromatic refractors; 3" achromat with folded optics from Unitron; and 3" to 6" achromats with folded optics from Photon Instruments.

*This telescope is sold by Sky Designs and Sky Instruments

Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers; prices may vary from dealer to dealer. n/a = data not available; opt. = optional; call = call manufacturer.

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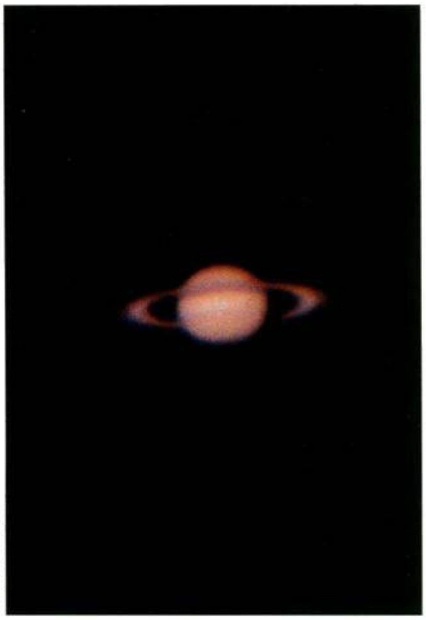

Mark Schmidt

A good telescope for a young astronomer needs to be child-friendly — easy to carry, easy to set up, easy to aim — with a low eyepiece height and simple construction that will withstand knocks and bumps. An 80mm to 90mm refractor ($450 to $550) fits the bill, but a more economical one might be a 4- to 6-inch Dobsonian-style reflector ($300 to $400).

For under $300, bypass a telescope altogether. Instead, buy a pair of 7 to 10 power binoculars with lenses at least 40mm across. (See "Selecting the Best Binoculars" for the details.) Complement these with a set of introductory star charts or a book on stargazing with binoculars. But most important, don't spend money, spend *time* — time under the night sky helping your child identify the planets, stars, and constellations with the unaided eye. For telescopic views, why not visit a local public observatory or an astronomy club's star party?

6 What does it take to see . . .

Craters on the Moon

A 60mm refractor at 50x can provide startling views of the Moon.

Rings of Saturn

Normally, any telescope will show the rings at only 75x to 150x. The larger the telescope, the sharper the rings will appear. But until early 1996 Saturn's rings will appear almost edge-on and will be difficult to see in any telescope.

The Red Spot on Jupiter

A 60mm to 90mm telescope will reveal the dark equatorial cloud belts on Jupiter as well as its four large moons. But Jupiter's Red Spot can be elusive. It is often a pale pink or even gray, and can be hidden amid other cloud structures. In that case it can be tough to see in even an 8- to 12-inch telescope.

Apochromatic Refractors

Manufacturer	Model	Aperture (in.)	f/ratio	Lens design	Mount design	Drive	Finder	Focuser size (in.)	Average selling price
Small Refractors									
Tele Vue	Pronto*	2.8	6.8	Doublet ED Semi-Apo	opt.	—	opt.	2	$850
Takahashi	FC-60SB	2.4	8.3	Doublet Fluorite Apo	German equatorial	DC	5x25	1.34	$2,717
Takahashi	FS-102H	3	7.9	Doublet Fluorite Apo	German equatorial	DC	7x50	2	$4,779
Zeiss	ED 80/840	3.1	10.5	Doublet ED Apo	opt.	—	7.5x42	2.4	$2,850
Tele Vue	Ranger	2.8	6.8	Doublet ED Semi-Apo	opt.	—	opt.	1.25	call
4-inch Refractors									
Tele Vue	Genesis SDF	4	5.4	4-el. SD+Fluorite Apo	opt.	—	opt.	2	$1,950
Meade	102ED Apo	4	9	Doublet ED Apo	German equatorial	opt.	8x50	2	$2,195
Tele Vue	Renaissance SDF	4	5.4	4-el. SD+Fluorite Apo	opt.	—	opt.	2	$2,250
Zeiss	AS 100/1000	4	10	Doublet Semi-Apo	opt.	—	7.5x42	2.7	$2,850
Takahashi	FS-78H	4	8	Doublet Fluorite Apo	German equatorial	DC	7x50	2.7	$3,825
Astro-Physics	105 Traveler EDT	4.1	5.8	Triplet ED Apo	German equatorial	DC	opt.	2.7	$4,223
Zeiss	APQ 100/1000	4	10	Triplet Fluorite Apo	opt.	—	7.5x42	2.7	$4,400
Takahashi	FS-102EN	4	8	Doublet Fluorite Apo	German equatorial	DC	7x50	2.7	$4,394
Zeiss	APQ 100/640	4	6.4	Triplet Fluorite Apo	opt.	—	7.5x42	2.7	$4,750
Celestron	C-102ED	4	9	Doublet ED Apo	German equatorial	opt.	6x30	1.25	call
5-inch Refractors									
D & G	5.1" Apochromat	5.1	9.5	Doublet ED Apo	opt.	—	8x50	2.7	$1,995
Meade	127ED Apo	5	9	Doublet ED Apo	German equatorial	opt.	8x50	2	$2,795
Astro-Physics	130 Starfire EDT	5.1	8	Triplet ED Apo	German equatorial	DC	opt.	2.7	$5,121
Astro-Physics	130 Starfire EDFS	5.1	6	Triplet ED Apo	German equatorial	DC	opt.	2.7	$7,846
Zeiss	APQ 130/1000	5	7.7	Triplet Fluorite Apo	opt.	—	7.5x42	2.7	$7,900
Takahashi	FS-128SE	5	8	Doublet Fluorite Apo	German equatorial	DC	7x50	2.7	$9,545
Takahashi	FS-128JP	5	8	Doublet Fluorite Apo	German equatorial	DC	7x50	2.7	$10,767
6-inch Refractors									
Meade	152ED Apo	6	9	Doublet ED Apo	German equatorial	opt.	8x50	2	$4,495
Astro-Physics	155 Starfire EDFS	6.1	7.1	Triplet ED Apo	German equatorial	DC	opt.	2.7	$7,846
Astro-Physics	155 Starfire EDF	6.1	7.1	Triplet ED Apo	German equatorial	DC	opt.	4	$10,935
Zeiss	APQ 150/1200	6	8	Triplet Fluorite Apo	opt.	—	7.5x42	2.7	$12,500
Takahashi	FCT-150	6	7	Triplet Fluorite Apo	German equatorial	DC	11x70	4	$36,333
Takahashi	FC-150	6	11.3	Doublet Fluorite Apo	German equatorial	DC	7x50	4	$36,333
Large Refractors									
Meade	178ED Apo	7	9	Doublet ED Apo	German equatorial	opt.	8x50	2	$5,495
Astro-Physics	180 Starfire EDT	7.1	9	Triplet ED Apo	German equatorial	DC	opt.	2.7	$10,160

NOTE: All telescopes on this list that include mounts also have manual or electric slow-motion controls and setting circles.

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*Pronto has optional solar viewing kit.

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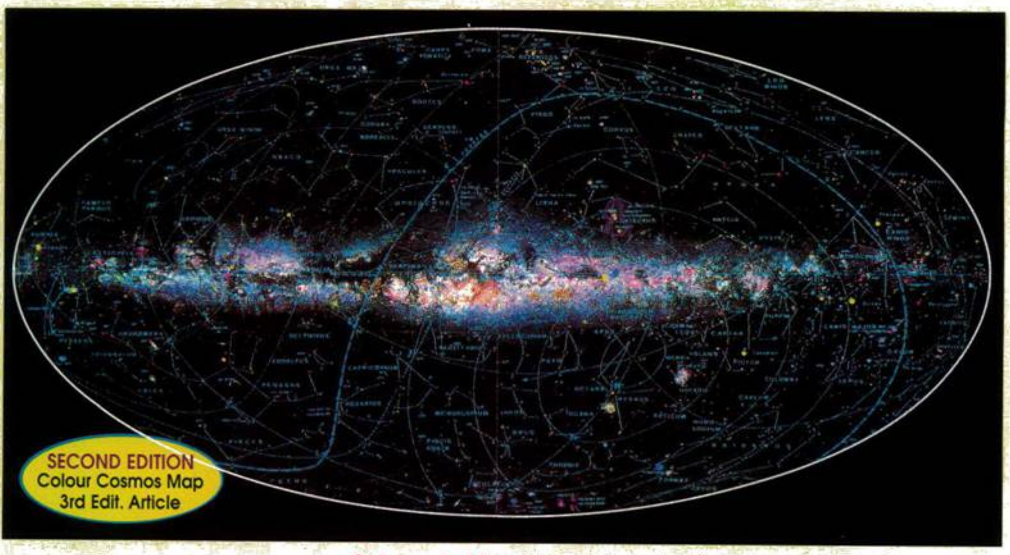

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Dobsonian & Altazimuth Reflectors

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Finder	Setting circles	Focuser size (in.)	Tube length (in.)	Total weight (lbs.)	Tube style	Average selling price
Small Altazimuth Newtonians											
Stargazer Steve	Sgr-3	3	10	0.80	√	—	1.25	30	8	Solid	$189
North Star Systems	4.25-inch	4.25	10	0.75	—	—	1.25	45	19	Solid	$230
Europtik	CR 2.6 Cosmotron	2.6	7.7	n/a	—	—	1.25	20	20	Solid	$320
Edmund	Astroscan 2001	4.2	4.2	2.12	—	—	1.25	17	13	Solid	$340
Compact Dobsonian Reflectors (6- to 10-inch)											
Orion	Deep Space Explorer	6	8	1.20	opt.	—	1.25	48	29	Solid	$319
Meade	Starfinder Dob.	6	8	1.18	opt.	—	1.25	48	44	Solid	$325
North Star Systems	6-inch	6	8	1.00	—	—	1.25	48	34	Solid	$330
Coulter	Odyssey 8 f/7	8	7	1.83	opt.	—	1.25	57	59	Solid	$240
Coulter	Odyssey 8	8	4.5	2.14	opt.	—	1.25	36	39	Solid	$275
Orion	Deep Space Explorer	8	6	1.52	opt.	—	1.25	48	39	Solid	$419
Meade	Starfinder Dob.	8	6	1.52	opt.	—	1.25	48	n/a	Solid	$425
North Star Systems	8-inch	8	6	1.30	—	—	1.25	48	45	Solid	$440
Starsplitter	Starsplitter Compact	8	6	1.52	Telrad	—	1.25	48	35	Truss	$799
Z Optical	Z-Scope	8	6	1.83	Telrad	opt.	1.25	52	51	Solid	$795
Sunrise	8" Dob.	8	5	n/a	Telrad	opt.	1.25	n/a	35	Truss	$850
Coulter	Odyssey Compact	10.1	4.5	2.60	opt.	—	1.25	46	65	Solid	$345
Meade	Starfinder Dob.	10	4.5	2.37	opt.	—	1.25	45	61	Solid	$595
Orion	Deep Space Explorer	10	5.6	2.14	opt.	—	1.25	56	68	Solid	$599
North Star Systems	10-inch	10	5.6	1.83	—	—	1.25	56	72	Solid	$620
North Star Systems	10-inch	10	4.5	1.83	—	—	1.25	45	65	Solid	$668
Orion	Prem. Deep Space Explorer	10	5.6	2.14	opt.	—	2	62	88	Solid	$749
Starsplitter	Starsplitter Compact	10	6	1.83	Telrad	—	1.25	60	40	Truss	$999
Z Optical	Z-Scope	10	5	2.60	Telrad	opt.	1.25	53	65	Solid	$995
Sunrise	10" Dob.	10	5	n/a	Telrad	opt.	1.25	n/a	41	Truss	$1,100
Mid-sized Dobsonian Reflectors (12- to 15-inch)											
Meade	Starfinder Dob.	12.5	4.8	2.60	opt.	—	1.25	58	97	Solid	$795
Orion	Deep Space Explorer	12.5	4.8	2.60	opt.	—	1.25	60	85	Solid	$779
Orion	Prem. Deep Space Explorer	12.5	4.8	2.60	opt.	—	2	65	101	Solid	$899
Z Optical	Z-Scope	12.5	5	2.60	8x50	Yes	2	80	127	Solid	$995
Cusick	Starhunter 1	12.5	4.8	n/a	Telrad	—	2	n/a	80	Truss	$1,199
Starsplitter	Starsplitter Compact	12.5	5	2.60	Telrad	—	2	63	50	Truss	$1,499
Sunrise	12.5" Dob.	12.5	5	n/a	Telrad	opt.	2	n/a	77	Truss	$1,650
Torus	12.5" Dob.	12.5	5.6	2.14	Telrad	—	2	72	60	Truss	$2,300
MAG 1	PortaBall 1	12.5	4.8	2.60	Telrad	—	2	65	69	Truss	$2,495
Starsplitter	Starsplitter II	12.5	4.8	2.60	Telrad	—	2	63	80	Truss	$2,495
Starsplitter	Starsplitter II	12.5	6	2.60	Telrad	—	2	63	80	Truss	$2,495
Coulter	Odyssey 1	13.1	4.5	3.10	opt.	—	1.25	58	100	Solid	$575
Sunrise	14" Dob.	14	5	n/a	Telrad	opt.	2	n/a	90	Truss	$2,785
Sky Designs	14.5 VPT Ultralite	14.5	4.5	3.10	—	—	2	65	70	Truss	$2,350
Tectron	15" Dob.	15	5	2.14	Telrad	—	2	75	100	Truss	$2,400
Obsession	Obsession 15	15	4.5	2.60	—	opt.	2	58	65	Truss	$2,795
Torus	14.5" Dob.	14.5	5.5	2.14	Telrad	—	2	76	85	Truss	$2,964
Starsplitter	Starsplitter II	14.5	5.2	2.60	Telrad	—	2	74	95	Truss	$2,995
Large Dobsonian Reflectors (16- to 20-inch)											
Coulter	Odyssey 2	16	4.5	4.25	opt.	—	1.25	72	150	Solid	$695
Meade	Starfinder Dob.	16	4.5	4.00	opt.	—	1.25	66	170	Solid	$895
Orion	Prem. Deep Space Explorer	16	4.5	3.50	opt.	—	2	75	175	Solid	$1,799
Sunrise	16" Dob.	16	5	2.60	Telrad	opt.	2	n/a	107	Truss	$3,290
Starsplitter	Starsplitter II	16	4.7	3.10	Telrad	—	2	76	105	Truss	$3,295
Torus	16" Dob.	16	5.5	2.60	Telrad	—	2	78	100	Truss	$3,500
Safari	Safari 18	18	4.5	3.10	—	—	2	70	148	Truss	$3,100
Sky Designs	18" VPT	18	4.5	3.50	—	—	2	77	110	Truss	$3,250
Tectron	18" Dob.	18	5	2.10	Telrad	—	2	90	160	Truss	$3,350
Sunrise	18" Dob.	18	5	3.10	Telrad	opt.	2	n/a	129	Truss	$3,490
Starsplitter	Starsplitter II	18	4.5	3.10	Telrad	—	2	81	115	Truss	$3,595
Obsession	Obsession 18	18	4.5	3.10	—	opt.	2	72	95	Truss	$3,895
Torus	18" Dob.	18	5	2.60	Telrad	—	2	91	120	Truss	$4,175
Tectron	20" Dob.	20	5	2.60	Telrad	—	2	100	150	Truss	$3,700
Sunrise	20" Dob.	20	5	3.10	Telrad	opt.	2	n/a	149	Truss	$3,790
Starsplitter	Starsplitter II	20	5	3.10	Telrad	—	2	96	170	Truss	$4,095
Sky Designs	20" VPT	20	4	4.00	—	—	2	78	150	Truss	$4,350
Obsession	Obsession 20	20	5	3.10	—	opt.	2	94	130	Truss	$4,495
Starsplitter	Starsplitter II	20	4	3.50	Telrad	—	2	78	170	Truss	$4,595
Torus	20" Dob.	20	5	3.10	Telrad	—	2	102	150	Truss	$4,725
Obsession	Obsession 20	20	4	3.50	—	opt.	2	74	120	Truss	$4,995
Giant Dobsonian Reflectors (22-inch and up)											
Starsplitter	Starsplitter II	22	4.5	3.50	Telrad	—	2	98	220	Truss	$5,995
Sunrise	25" Dob.	25	5	4.00	Telrad	opt.	2	n/a	247	Truss	$6,390
Torus	22" Dob.	22	5	2.60	Telrad	—	2	110	200	Truss	$6,600
Tectron	24" Dob.	24	4.5	3.50	Telrad	—	2	108	160	Truss	$7,500
Obsession	Obsession 25	25	5	3.50	—	opt.	2	115	220	Truss	$8,895
Starsplitter	Starsplitter II	25	4	4.00	Telrad	—	2	100	250	Truss	$8,995
Torus	24" Dob.	24	5	3.50	Telrad	—	2	115	240	Truss	$9,450
Obsession	Obsession 25	20	4	4.50	—	opt.	2	94	200	Truss	$9,595
Sky Designs	24" VPT	24	4	n/a	—	—	2	n/a	n/a	Truss	call

Nebulae

The brightest clouds of glowing gas called nebulae show up in even an 80mm telescope, but the bigger the telescope the more nebulosity you'll see. Just don't expect to see the reds and blues you see in photographs — it takes long exposures to reveal these vivid colors. To the telescopic eye, deep-sky targets appear gray-green.

Martin Bernier

Globular clusters

These spherical clusters of stars appear in binoculars and small (2.4- to 4-inch) telescopes as fuzzy patches. It takes at least a 6-inch telescope to resolve them into stellar pinpoints.

The Andromeda Galaxy

It's the spiral galaxy nearest to our Milky Way. From a dark site you can actually see it with unaided eye. Binoculars show it quite well. Through a telescope it appears bigger and brighter but still appears as a fuzzy glow — no backyard telescope can resolve this object into stars.

Other galaxies

Beyond Andromeda thousands of other galaxies lie within reach of backyard telescopes. An 80mm to 90mm refractor can show the brightest galaxies as hazy patches and slivers of light, but seeing spiral arms and dust lanes in these distant denizens requires at least a 6- to 8-inch telescope.

7 How far can I see? How faint can I see?

With just your eyes you can see two million light-years, the distance to the Andromeda Galaxy. A backyard telescope can reveal galaxies hundreds of times farther away. Yet Pluto at the edge of the solar system can remain elusive.

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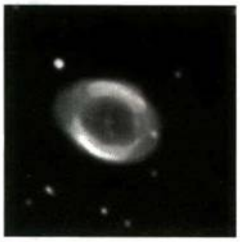

Note the fine detail in this high-resolution CCD image taken with the HD216 and a HiSIS22 camera. Processing with HIDDEN IMAGE software by Sehgal Corp.

The HD216 8.5" f/6 Maksutov-Newtonian telescope shown with the Byers Series II CT equatorial mount. Custom mount configurations from Astro-Physics and Celestron-Losmandy are also available. Basic optical tube assembly prices start at $4350.

The HD216's diffraction-limited optics, ultra-small diagonal and lack of spider diffraction ensure high-contrast images.

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Equatorial Reflectors

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Slow motion	Setting circles	Finder	Focuser size (in.)	Average selling price
Small Newtonians (3- to 5-inch)											
Edmund	#S31-308	3	6	1.40	Equatorial fork	—	—	—	—	1.25	$219
Cosmos	4.25" Newtonian	4.25	8	1.25	opt.	—	—	—	opt.	1.25	$249
Cosmos	4.25" Newtonian	4.25	6	1.10	opt.	—	—	—	opt.	1.25	$275
Cosmos	4.5" Newtonian	4.5	8	1.00	German equatoria	opt.	√	√	6x30	1.25	$395
Orion	Skyview 4.5	4.5	7.8	1.80	German equatorial	opt.	√	√	6x30	1.25	$399
Meade	#4500	4.5	8	1.13	German equatorial	—	√	√	6x30	1.25	$399
Europtik	CR 4.5 Cosmotron	4.5	7.3	n/a	German equatorial	opt.	√	√	6x30	1.25	$450
Tasco	#302911	4.5	4.4	1.06	German equatorial	opt.	√	√	5x24	.965	$476
Simmons	#6450	4.5	7.2	1.25	German equatorial	—	√	√	5x24	.965	$600
Sky Des./Instr.*	Omcon 811D	4.5	8	1.06	German equatorial	DC	√	√	6x30	1.25	$600
Tasco	#302012	4.5	7.9	1.06	German equatorial	opt.	√	√	5x24	.965	$688
Swift	#853	4.5	7.9	1.06	German equatorial	opt.	√	√	5x24	.965	$698
Tasco	#302013	4.5	7.9	1.06	German equatorial	opt.	√	√	6x30	1.25	$1,102
Celestron	C4.5	4.5	7.9	1.17	German equatorial	opt.	√	√	6x30	1.25	call
Celestron	Firstscope 114	4.5	8	1.17	German equatorial	opt.	√	√	5x24	1.25	call
Sky Designs	Omcon 813D	5	8	n/a	German equatorial	opt.	√	√	6x30	1.25	call
6-inch Newtonians											
Cosmos	6" Newtonian	6	8	1.25	opt.	—	—	—	opt.	1.25	$345
Cosmos	6" Newtonian	6	6	1.50	opt.	—	—	—	opt.	2	$395
Iowa Scientific	NWT-608	6	8	1.25	German equatorial	opt.	√	opt.	6x30	1.25	$835
Iowa Scientific	NWT-605	6	5	1.50	German equatorial	opt.	√	opt.	6x30	1.25	$845
Meade	Starfinder Eq.	6	8	1.18	German equatorial	AC	—	√	6x30	1.25	$599
Sky Instr.	Omcon 515	6	5	2.00	German equatorial	DC	√	√	6x30	1.25	$700
Parks	Precision	6	8	1.33	German equatorial	opt.	opt.	opt.	6x30	1.25	$799
Parks	Precision	6	6	1.55	German equatorial	opt.	opt.	opt.	6x30	1.25	$799
Europtik	CR 6 Cosmotron	6	n/a	n/a	German equatorial	opt.	√	√	6x30	1.25	$995
Parks	Astrolight	6	8	1.33	German equatorial	opt.	√	√	6x30	1.25	$999
Parks	Astrolight	6	6	1.55	German equatorial	opt.	√	√	6x30	1.25	$999
Iowa Scientific	PNT-612	6	12	0.75	German equatorial	opt.	√	opt.	6x30	1.25	$1,050
Star Liner	Econoline	6	8	n/a	German equatorial	AC	—	√	6x30	1.25	$1,400
Star Liner	Quality	6	8	n/a	German equatorial	AC	√	√	6x30	1.25	$2,700
Sky Designs	Omcon 715T	6	6.7	n/a	German equatorial	opt.	√	√	8x50	2	call
8-inch Newtonians											
Celestron	GP-C200	7.9	4	2.40	German equatorial	opt.	√	√	6x30	2	call
Cosmos	8" Newtonian	8	6	1.83	opt.	—	—	—	opt.	2	$545
Meade	Starfinder Eq.	8	6	1.52	German equatorial	AC	—	√	6x30	1.25	$699
Iowa Scientific	NWT-806	8	6	1.50	German equatorial	opt.	√	opt.	6x30	2	$1,050
Parks	Precision	8	6	1.83	German equatorial	opt.	opt.	opt.	6x30	1.25	$1,199
Sky Instr.	Antares 620	8	6	2.0	German equatorial	DC	√	√	opt.	2	$1,200
Star Liner	Econoline	8	7	n/a	German equatorial	AC	—	√	6x30	1.25	$1,590
Parallax	PI 200	8	7.5	1.50	opt.	—	—	—	8x50	2.7	$1,695
Parks	Superior	8	6	1.83	German equatorial	DC	√	√	8x50	2	$2,499
Star Liner	Quality	8	7	n/a	German equatorial	AC	√	√	6x30	1.25	$3,200
Sky Designs	Omcon 520T	8	5	n/a	German equatorial	opt.	√	√	8X50	2	call
RVR	SX-210	8.25	6.7	n/a	German equatorial	DC	√	√	8x50	2	call
10-inch Newtonians											
Meade	Starfinder Eq.	10	4.5	2.37	German equatorial	AC	—	√	6x30	1.25	$799
Sky. Instr.	Antares 625	10	5.6	2.00	German equatorial	DC	√	√	opt.	2	$1,400
Parallax	PI 250	10	6.5	1.83	opt.	—	—	—	8x50	2.7	$2,095
Star Liner	Quality	10	6	n/a	Equatorial fork	AC	√	√	10x50	2	$2,150
Parks	Superior	10	5	2.60	German equatorial	DC	√	√	8x50	2	$2,899
Optical Guid.	10" Newtonian	10	5	3.50	German equatorial	DC	√	√	8x50	2.5	$7,015
Large Portable Newtonians (12-inch and larger)											
Parks	Superior	12.5	5	3.10	German equatorial	DC	√	√	8x50	2	$3,999
JMI	NGT 12.5	12.5	4.5	2.60	Split-ring equatorial	DC	√	√	8x50	2	$4,500
Light Speed	Light Speed 12.5	12.5	5.6	2.10	Equatorial fork	DC	√	√	8x50	2	$8,500
Meade	Starfinder Eq.	16	4.5	4.00	German equatorial	AC	—	√	8x50	2	$2,495
Light Speed	Light Speed 16	16	5.75	2.60	Equatorial fork	DC	√	√	9x60	2	$21,975
JMI	NGT 18	18	4.5	4.00	Split-ring equatorial	DC	√	√	9x60	2	$11,000
Light Speed	Light Speed 20	20	5	4.00	Equatorial fork	DC	√	√	9x60	2	$25,975
JMI	NTT 25	25	5	9.00	Computerized altaz	DC	√	√	11x80	2	$30,000

NOTE: See "Other Reflectors" table for more listings of large-aperture equatorial reflectors.

*This telescope is sold by Sky Designs and Sky Instruments.

Telescopes listed in order of increasing aperture. Telescopes of same or similar aperture listed in order of increasing price. Prices are typical selling prices at full-service dealers; prices may vary from dealer to dealer. n/a = data not available; opt. = optional; call= call manufacturer.

The significant factor is not distance, but dimness. How faint an object your telescope can reveal depends on the scope's aperture. Celestial objects are ranked by their magnitude — the dimmer the object, the higher its magnitude number. With just your unaided eye you can see stars down to magnitude 6. Binoculars reveal magnitude 9 stars. Under good conditions, a 4-inch telescope penetrates down to magnitude 12.7. Many galaxies hover in the magnitude 10 to 14 range.

8 What is better — a refractor or reflector?

Neither type has a clear advantage. Refractors use lenses to gather and focus light. When made right, they provide sharp images in a rugged instrument requiring little maintenance, all good traits for a beginner's scope. But in apertures over 90mm, they are expensive, with costs of $400 to $1,000 per inch of aperture not unusual for 4-inch and larger refractors.

Reflectors use mirrors to gather light. A reflector usually doesn't provide quite as sharp an image as a top-notch refractor of the same aperture, but you can buy a much larger reflector for the money — they run about

John Hicks

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Alan Dyer

$50 to $300 per inch of aperture, with most of the price variations stemming from the type of mount.

9 Don't reflectors need lots of maintenance?

Reflectors sometimes need collimation. The most common type of reflector is the Newtonian — it uses a large concave primary mirror at the bottom of the tube coupled with a small flat secondary mirror at the top.

To keep star images looking symmetrical and planet images looking sharp both mirrors must be tilted just right. Adjusting the mirrors is not difficult and needs to be performed only every few months at most.

The main mirror can collect dust and grime. Cleaning a delicate mirror is easy but should be done only infrequently and carefully. Realuminizing a mirror — recoating its surface with a new reflective layer — will be required only after many years of use.

These minor maintenance chores are a small price to pay for the reflector's value.

10 What's an apochromatic refractor?

An imperfection of large refractors called chromatic aberration adds a faint purple glow around all bright objects. Apochromatic refractors (often called "apos") use special types of glass to eliminate this false color. Available in 3- to 7-inch apertures, these refractors provide top-quality images but at a premium price.

Catadioptric Telescopes

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Speed controls?	Finder	Focuser size (in.)	Total weight (lbs.)	Average selling price
Small Schmidt-Cassegrains (3- to 5-inch)											
Swift	#854	3.1	12.5	n/a	Equatorial fork	—	—	4x20	1.25	9	$1,050
Meade	#2045D	4	10	1.80	Equatorial fork	DC	—	5x24	1.25	13	$699
Parks	Jovian–4	4	10	1.00	—	—	—	5x24	1.25	4	$1,200
Swift	#856	4.5	8.7	n/a	German equatorial	opt.	—	6x30	.965	21	$950
Celestron	C5	5	10	2.00	Equatorial fork	AC	—	5x24	1.25	23	call
Celestron	C5+	5	10	2.00	Equatorial fork	DC	√	5x24	1.25	23	call
8 to 9 1/4-inch Schmidt-Cassegrains											
Meade	LX50	8	10	3.00	Equatorial fork	DC	√	8x50	1.25	66	$1,195
Celestron	C8+	8	10	2.75	Equatorial fork	DC	√	6x30	1.25	28	call
Celestron	C8+ Computer	8	10	2.75	Equatorial fork	DC	√	6x30	1.25	30	call
Celestron	Ultima 8-PEC	8	10	2.75	Equatorial fork	DC	√	7x50	1.25	66	call
Celestron	GP-C8	8	10	2.75	German equatorial	opt.	√	6x30	1.25	45	call
Celestron	Celestial 8	8	10	2.75	Equatoria forkl	DC	√	6x30	1.25	26	call
Meade	LX200	8	10	3.00	Computerized altaz	DC	√	8x50	1.25	61	$2,495
Meade	LX200	8	6.3	3.45	Computerized altaz	DC	√	8x50	1.25	61	$2,295
Celestron	CG-9.1/4	9.25	10	3.00	German equatorial	DC	√	6x30	1.25	81	call
Celestron	Ultima 9.1/4	9.25	10	3.00	Equatorial fork	DC	√	6x30	1.25	74	call
10- to 16-inch Schmidt-Cassegrains											
Meade	LX50	10	10	3.70	Equatorial fork	DC	√	8x50	1.25	89	$1,795
Meade	10" LX200	10	10	3.70	Computerized altaz	DC	√	8x50	1.25	85	$2,895
Meade	10" LX200	10	6.3	4.00	Computerized altaz	DC	√	8x50	1.25	85	$2,895
Celestron	CG-11	11	10	4.00	German equatorial	DC	√	7x50	1.25	99	call
Celestron	Ultima 11	11	10	4.00	Equatorial fork	DC	√	7x50	1.25	84	call
Meade	12" LX200	12	10	4.00	Computerized altaz	DC	√	8x50	2	120	$3,995
Celestron	Compustar 14	14	11	4.50	Equatorial fork	DC	√	7x50	2	181	call
Celestron	CG-14	14	10	4.50	German equatorial	DC	√	7x50	2	135	call
Meade	16" LX200	16	10	5.00	Computerized altaz	DC	√	8x50	2	160	$14,995
Maksutov-Newtonians and Maksutov-Cassegrains											
Questar	3.5 Standard	3.5	14.4	1.18	Equatorial fork	AC/DC	—	6x	1.25	8	$3,475
Questar	3.5 Duplex	3.5	14.4	1.18	Equatorial fork	AC/DC	√	6x	1.25	8	$3,750
Ceravolo	HD145*	5.7	6	1.00	opt.	—	—	—	2	12	$1,895
FJR Manuf.	Vega 6*	6	4	1.50	German equatorial	DC	√	6x30	2	60	$5,800
Meade	LX50	7	15	2.00	Equatorial fork	DC	√	8x50	1.25	72	$1,595
Meade	LX200	7	15	2.00	Computerized altaz	DC	√	8x50	1.25	67	$1,595
Questar	Questar 7	7	14.4	2.35	—	—	—	12x	1.25	22	$7,195
Ceravolo	HD216*	8.5	6	1.50	opt.	—	—	—	2	30	$4,350
Ceravolo	HD355 Custom*	14	5	2.60	opt.	—	—	—	2	100	$18,000

*These telescopes are Maksutov Newtonians; other Maksutovs are Cassegrain designs.

call = call manufacturer.

11 What's a Schmidt-Cassegrain telescope?

One of the most popular telescopes for serious amateur astronomers is neither a refractor or reflector, but a hybrid of both. The Schmidt-Cassegrain uses a mirror to collect light but also incorporates a lens-like corrector plate to cancel out an optical distortion called spherical aberration. (Other types of hybrid instruments exist — collectively they're all called catadioptric instruments, or "cats.")

Schmidt-Cassegrains offer generous aperture in a compact and versatile package. Costs run about $200 to $400 per inch of aperture, putting them midway between Newtonian reflectors and top-quality refractors in price.

12 Which is better — f/6 or f/10?

A specification you'll often see listed is a telescope's focal ratio. This is simply the telescope's focal length divided by its aperture. The focal length is the effective distance from the lens or mirror to the point where the light reaches focus. A 2000mm-focal length telescope with an aperture of 8 inches (200mm) has an f/ratio of f/10.

Telescopes come in a range of f/ratios, from f/4 to f/15. One type is not better than another. Contrary to popular misconception, an f/6 telescope is not brighter than an f/10. Take two telescopes of any f/ratio you like — as long as their apertures and magnifications are the same, the telescopes will produce eyepiece images with exactly the same brightness.

Luke Dodd

However, refractors and reflectors in the f/4-to-f/6 range have compact, portable tubes and yield low power and wide fields of view, traits suited to deep-sky viewing and astrophotography.

On the other hand, telescopes with f/ratios greater than 6 often have slightly better optical quality (it's harder to make

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an f/4 mirror really well) and top-notch optics are essential for sharp views of planets. But when made well, telescopes of any f/ratio can yield satisfying images of all types of objects.

13 What are good features on a telescope?

A solid mount

Great optics are worthless if they're placed on a shaky mount. If the mount looks flimsy, chances are it is. Try to wiggle the telescope — there shouldn't be any play or looseness in the mount. Give the telescope a rap — the image will bounce around but should settle down in no more than 2 to 3 seconds.

Slow motion controls

Some kind of fine adjustment on both axes of the mount is a definite plus on most telescopes. Exceptions are Dobsonian-mounted telescopes — their smooth bearing surfaces make it easy to nudge the telescope to center objects.

A good finderscope

All telescopes require some type of sighting device to help you aim the telescope. A 6-power 30mm-aperture finderscope (designated as 6x30) is common. An 8x50 is even better. Unfortunately,

Other Reflectors

Manufacturer	Model	Aperture (in.)	f/ratio	Secondary mirror size (in.)	Mount design	Drive	Speed controls	Finder	Focuser size (in.)	Total weight (lbs.)	Average selling price
Richfield Newtonians (Ultrafast f/ratio reflectors)											
Cosmos	Wide Field	4.25	5	1.25	opt.	—	—	opt.	1.25	7	$295
Cosmos	Ultra-wide Field	4.25	4	1.52	opt.	—	—	opt.	1.25	6	$347
Parks	Companion	4.5	5	1.33	—	—	—	6x30	1.25	5	$499
Cosmos	Wide Field	6	5	1.80	opt.	—	—	opt.	2	13	$449
Cosmos	Ultra-wide Field	6	4	2.14	opt.	—	—	opt.	2	12	$495
Parks	Nitelight	6	3.5	1.83	German equatorial	opt.	√	6x30	1.25	55	$1,199
Star Liner	Richfield	6	4		German equatorial	AC	—	6x30	1.25	70	$2,990
Cosmos	Wide Field	8	5	2.14	opt.	—	—	opt.	2	21	$595
Parks	Nitelight	8	3.5	2.60	German equatorial	opt.	√	8x50	2	65	$1,399
Parks	Superior Nitelight	8	3.5	2.60	German equatorial	DC	√	8x50	2	165	$2,799
Star Liner	Richfield	8	4		German equatorial	AC	—	6x30	1.25	75	$3,200
Cosmos	Ultra-wide Field	10	4.5	2.80	opt.	—	—	opt.	2	27	$895
Parks	Nitelight	10	3.5	3.10	German equatorial	DC	√	8x50	2	198	$3,199
Star Liner	Richfield	10	4	n/a	German equatorial	AC	—	10x50	2	150	$4,175
Star Liner	Richfield	12.5	4	n/a	German equatorial	AC	—	10x50	2	200	$4,890
Parks	Nitelight	12.5	3.5	4.00	German equatorial	DC	√	8x50	2	235	$4,999
Parks	Nitelight	16	3.5	5.00	German equatorial	DC	√	8x50	2	605	$14,099
Tilted-Component Telescopes (Long-focus unobstructed reflectors)											
Iowa Scientific	SCH-426	4.25	26	—	German equatorial	opt.	—	6x30	2	45	$1,300
Iowa Scientific	SCH-630	6	30	—	German equatorial	opt.	—	6x30	2	55	$1,775
Portable Cassegrains and Combination Newtonian/Cassegrains (6- to 12-inch models)											
Parks	HIT Newt./Cass.	6	3.5/12	1.8/2.1	German equatorial	DC	—	6x30	1.25	70	$2,299
Takahashi	Mewlon 180ES	7	12	2.10	German equatorial	DC	√	7x50	2	68	$3,995
Star Liner	Quality Cass.	8	12	n/a	German equatorial	AC	—	6x30	1.25	120	$2,790
Parks	HIT Newt./Cass.	8	3.5/12	2.6/2.9	German equatorial	DC	—	8x50	2	81	$2,799
Star Liner	Newt./Cass.	8	4.0/12	n/a	German equatorial	AC	—	6x30	1.25	120	$3,740
Takahashi	Mewlon 210H	8.3	11.5	n/a	German equatorial	DC	√	7x50	2	78	$5,008
Takahashi	CN-212 Cass./Newt.	8.3	12.4/3.9	2.7/2.8	German equatorial	DC	√	7x50	2	80	$6,595
Star Liner	Quality Cass.	10	10	n/a	Equatorial fork	AC	—	10x50	2	145	$2,890
Star Liner	Newt./Cass.	10	4.8/10	n/a	Equatorial fork	AC	—	10x50	2	150	$3,295
Parks	HIT Newt./Cass.	10	3.5/12	3.1/3.5	German equatorial	DC	—	8x50	2	225	$4,599
Optical Guid.	CC10 Classical	10	15	3.50	German equatorial	DC	—	8x50	2	180	$8,575
Takahashi	Mewlon 250SE	10	12	3.10	German equatorial	DC	√	7x50	2	140	$9,795
Optical Guid.	RC10 Ritchey	10	8.5	4.60	German equatorial	DC	√	8x50	2.5	160	$13,075
RVR	SE-260	10.2	15	n/a	German equatorial	DC	√	8x50	2	950	call
Takahashi	Mewlon 300 SQI	12	11.9	3.00	German equatorial	DC	√	11x70	3	335	$20,995
Observatory Reflectors (12.5-inch and larger Newtonians, Cassegrains, and Combinations)											
Parallax	PI 320	12.5	6	2.14	opt.	—	—	8x50	2.7	70	$2,795
Star Liner	Quality Newt.	12.5	5	n/a	Equatorial fork	AC	—	10x50	2	180	$2,895
Star Liner	Quality Cass.	12.5	10	n/a	Equatorial fork	AC	—	10x50	2	190	$3,850
Star Liner	Newt./Cass.	12.5	3.8/11	n/a	Equatorial fork	AC	—	10x50	2	195	$4,250
Parks	HIT Newt./Cass.	12.5	3.5/12	4/4.2	German equatorial	DC	—	8x50	2	270	$6,599
Parks	Observatory	12.5	5	3.10	German equatorial	DC	√	8x50	2	515	$10,999
Optical Guid.	RC12.5 Ritchey	12.5	9	5.00	German equatorial	AC	—	8x50	2.5	240	$15,338
RVR	SE-310 Cass.	12.2	15	4.30	German equatorial	DC	√	8x50	2	1,016	call
Optical Guid.	RC14.5 Ritchey	14.5	7.9	6.00	German equatorial	AC	—	8x50	2.5	255	$19,785
Parks	Observatory	16	5	4.00	German equatorial	DC	√	8x50	2	695	$13,999
Parks	HIT Newt./Cass.	16	3.5/20	5/3.5	German equatorial	DC	—	8x50	2	635	$18,999
DFM	CCT-16	16	12	4.50	Equatorial fork	DC	√	9x60	—	350	$72,200
Alaska Appl.	16" Spgfd. Coude	16	12	6.00	Springfield, German	DC	√	8x50	3	400	call

Also available: 13.8" to 40" Cassegrains from RVR; 16" and 20" Ritchey-Chrétien Cassegrains from Optical Guidance Systems; 14.5" and 16" Newtonian tube assemblies from Parallax; 14.25" to 20" Newtonians, Cassegrains, Newtonian-Cassegrains from Star Liner; 20" Classical Cassegrains from D & G; and 30" and 40" Newtonians on computerized altazimuth mounts from JMI. Call = call manufacturer.

many 5x24 finders supplied on entry-level telescopes yield dim images.

A popular alternative is a reflex-style finder such as a Starbeam, Telrad, or QuikFinder. When you sight through these devices you see a red dot or bull's-eye pattern superimposed on a naked-eye view of the sky.

A smooth focuser

Rack the focuser in and out. It should slide easily and smoothly without any wobble. A sloppy focuser will cause endless frustration when you're trying to home in on the sharpest focus.

A 1.25-inch focuser at least

Many department-store telescopes accept only 0.965-inch diameter eyepieces. These are generally of poor quality. Eyepieces with the standard 1.25-inch barrel size are far superior. Look for telescopes that accept this size eyepiece.

Bill and Sally Fletcher

14 How do I find things?

The low-tech but economical way to explore the universe is to use star charts to find your way across the sky. It's called star-hopping — find a bright star, then use nearby stars as stepping stones to hop over to a deep-sky target. A good finderscope is essential. An alternative to awkward full-page charts are either AstroCards or Sky Spot charts — both are handy card-sized charts with one object per card.

To learn where the planets are, simply turn to ASTRONOMY magazine each month.

15 But I live in the city . . .

City lights won't wash out views of the Moon and planets. But only the brightest deep-sky objects (clusters, nebulae, and galaxies) will show up under urban skies, no matter what the telescope. A 3- to 10-inch scope of any type

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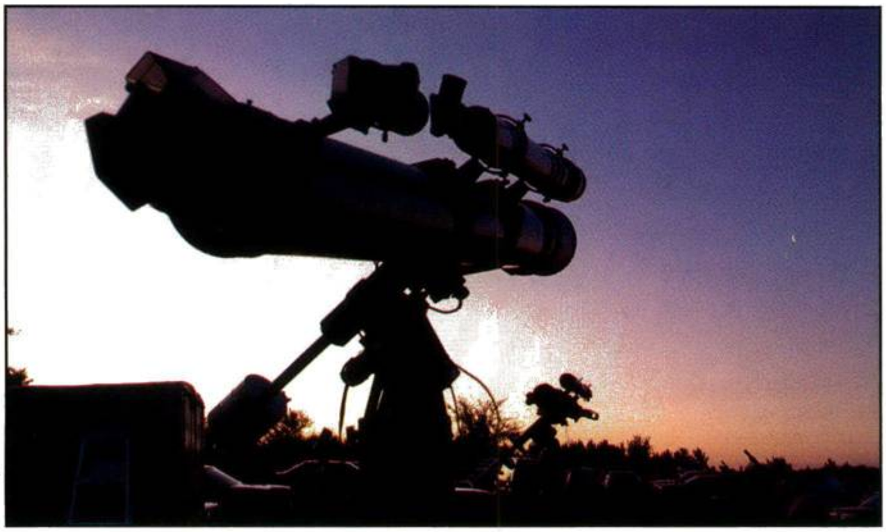

Alan Dyer

will work well in a city. Your prime consideration should be portability. How easy is it to carry the telescope in and out of your house or apartment and around your yard?

About the only telescope that's impractical in a city is one of the giant 14- to 24-inch Dobsonian reflectors. These "Galaxy-class starships" work best cruising dark rural skies.

16 Can I attach a camera to a telescope?

With a suitable camera adapter you can attach a 35mm camera body to most telescopes. But even if you have an equatorial mount, the only shots you'll be able to get easily through your telescope that

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These companies sell complete telescopes, optical tube assemblies, and telescope mounts.

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ASKO, c/o R.V.R. Optical, P.O. Box 62, Eastchester, NY 10709, (914) 337-4085.

Astro-Physics, 11250 Forest Hills Road, Rockford, IL 61111, (815) 282-1513.

Autoscope Corporation, 2637 Midpoint Drive, Suite D, Fort Collins, CO 80525, (303) 224-5439.

Bausch & Lomb Sport Optics Division, 9200 Cody, P.O. Box 14930, Overland Park, KS 66214, (913) 888-0220.

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DFM Engineering, Inc., 1035 Delaware Avenue, Unit D, Longmont, CO 80501, (303) 678-8143.

Edmund Scientific, 100 East Gloucester Pike, Barrington, NJ 08007, (609) 547-3488.

Edward's Telescopes, 14160 Community Street, Panorama City, CA 91402, (818) 894-7529.

Epoch Instruments, 2331 American Ave., Hayward, CA 94545, (415) 784-0391.

Europtik, Ltd., P.O. Box 319, Dunmore, PA 18512, (717) 347-6049.

FJR Manufacturing, Inc., 101 Progress Drive, West Bend, WI 53095, (414) 338-3389.

Fraunhofer Systems Company, 14418 Dickens Street, Suite #6, Sherman Oaks, CA 91423, (818) 986-3601.

Handmade Telescopes, 2906 Spooky Nook Road, Manheim, PA 17545, (717) 898-3089.

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JMI (Jim's Mobile Industries), 810 Quail Street, Unit E, Lakewood, CO 80215, (303) 233-5353.

Light Speed Telescopes, Inc., 3991 Weld County Road, #18 East Unit, Erie, CO 80516, (303) 678-9547.

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Meade Instruments Corporation, 16542 Millikan Avenue, Irvine, CA 92714, (714) 756-2291.

North Star Systems, P.O. Box 99, Ellenburg Depot, NY 12935. (518) 594-7250.

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Optical Guidance Systems, 2450 Huntingdon Pike, Huntingdon Valley, PA 19006, (215) 947-5571.

Optomechanics Research, Box 87, Vail, AZ 85641, (602) 647-3332.

Orion Telescope Center, 2450 17th Avenue, P.O. Box 1158, Santa Cruz, CA 95061, (800) 447-1001.

Parallax Instruments, 8318 Pineville-Matthews Road, Suite 708, Box 192, Charlotte, NC 28226, (704) 542-4817.

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Safari Telescopes, 110 Pascask Road, Pearl River, NY 10965, (914) 735-4163.

Selsi Company, Inc., 40 Veterans Blvd., Carlstadt, NJ 07072, (201) 935-0388.

Simmons Outdoor Corporation, 14530 SW 119 Ave., Miami, FL 33186, (305) 252-0477.

Sky Designs, 4100 Felps, Suite C, Colleyville, TX 76034, (817) 581-9878.

Sky Instruments, P.O. Box 3164, Vancouver, B.C., Canada V6B 3Y6, (604) 270-2813.

Star-Liner Company, 1106 S. Columbus Blvd., Suite B, Tucson, AZ 85711, (602) 795-3361.

Starsplitter Telescopes, 3228 Rikkard Drive, Thousand Oaks, CA 91362, (805) 493-2489.

Sunrise Telescopes, 2470 Stearns Street, Suite 291, Simi Valley, CA 93063, (805) 584-1567.

Swift Instruments, Inc., 952 Dorchester Ave., Boston, MA 02125, (617) 436-2960.

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Tasco, 7600 MW 26th St., Miami, FL, 33122, (305) 591-3670.

Tectron, 2111 Whitfield Park Avenue, Sarasota, FL 34243, (813) 758-9890.

Tele Vue Optics, Inc., 100 Route 59, Suffern, NY 10901, (914) 357-9522.

Torus Optical Works, 67 Bon-Aire, Iowa City, IA 52240, (319) 339-0524.

Unitron, 170 Wilbur Place, P.O. Box 469, Bohemia, NY 11716, (516) 589-6666.

Z Optical Shop, 2810 S. Main, Stafford, TX 77477, (713) 499-4993.

Zeiss (Carl Zeiss Jena GmbH), Astronomical Instruments Division, Postfach 125, Tatzendpromenade 1A, Jena, GERMANY, 0-6900, (49) 3641-588-2557; in North America contact Barlow Pepin, General Agent, 783 S. Atmore Circle, Deltona, FL 32725, (904) 789-5007.

will look sharp will be of the Moon.

Someday you'll probably want to shoot colorful nebulae and galaxies. This type of astrophotography is demanding and an entry-level telescope simply will not suffice. You'll need a telescope with a solid equatorial mount, precision dual-axis drive, and speed controls to allow you to guide the telescope. Be prepared to spend at least $1,800 to $3,000 for an astrophoto-ready telescope and accessories.

If that sounds a bit expensive, not to worry — you can take many astrophotos with just a camera on a tripod, or a camera riding piggyback on a driven equatorial telescope. Get your feet wet with these simple techniques before leaping into the deep end of deep-sky photography.

17 What telescope's the best buy?

The telescope market now contains some superb low-cost telescopes. The current crop of 6- to 8-inch Dobsonian-style reflectors offered by several manufacturers is impressive. And the one-of-a-kind 4-inch Edmund Astroscan remains a great starter scope. Although offering a smaller aperture, an 80mm or 90mm refractor provides a rugged, no-fuss telescope.

Ask yourself if you really want to take astrophotos. If not, then any of these telescopes on their basic altazimuth or Dobsonians mounts will serve you well, for under $600 each.

Jack Newton

Adding a good equatorial mount and motor drive adds at least limited astrophoto capability and the convenience of hands-off tracking. But if you are serious about astrophotography, look at nothing less than a well-equipped 5- to 8-inch Schmidt-Cassegrain or 4- to 5-inch apochromatic refractor. Most commercially-made Newtonian reflectors, while great for visual use, have equato-

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Dale Nartker

rial mounts and drives a notch short of the quality needed for long-exposure deep-sky photography.

If you're after super-sharp views of planets, consider a 5- to 7-inch apochromatic refractor, a long-focus f/7 to f/8 Newtonian reflector, or a premium Maksutov telescope (a type of catadioptric).

If spiral galaxies and faint nebulae are your quest, then a large-aperture 10- to 24-inch reflector on a Dobsonian mount is for you.

18 Am I ready to buy a telescope?

This last question is one buyers rarely ask. But before we leave the shopping mall of scopes, ask yourself if you know the sky well enough to put a telescope to good use. Can you identify the brightest stars? The major constellations? Can you locate the Orion Nebula in binoculars? The Double Cluster? The Andromeda Galaxy? If not, how will you find them in a telescope?

The biggest mistake people make is not buying the wrong brand or type of telescope but buying a telescope, period — at least before they are ready to use one. Those premature telescopes inevitably end up collecting dust, not starlight.

Spend a year learning the sky first with no more than simple star charts and binoculars. Then when you do make the leap, instead of wondering what to look at on your first nights out you'll actually be able to find and appreciate all the incredible sights every telescope is capable of revealing.

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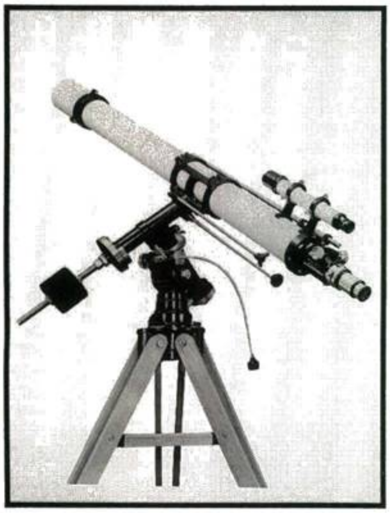

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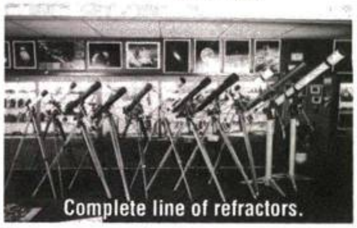

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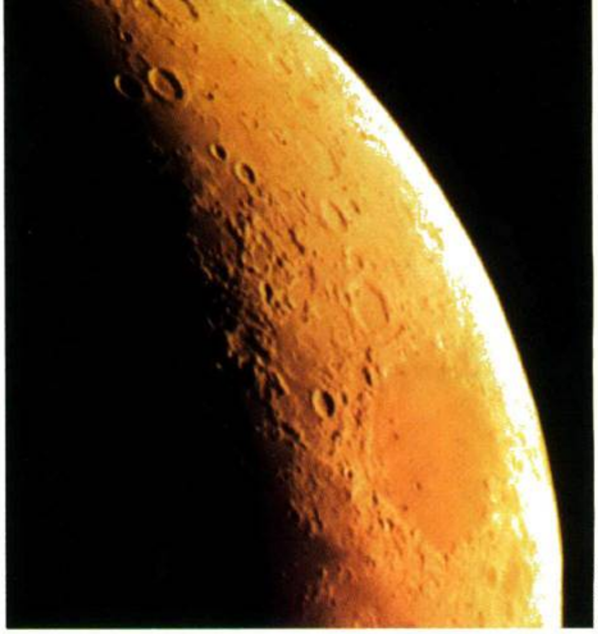

Mark Killion

Binoculars come in all sizes and varieties, for every application from bird-watching to ball games. For astronomy the choice narrows somewhat. If you are selecting a pair exclusively for nighttime use under the stars, pick either a 7x50 or 10x50 model. The "50" refers to the diameter of the front lenses in millimeters. The "7" or "10" refers to the magnification.

A 50mm binocular is larger than usually required for daytime use, but hunting faint celestial targets at night requires aperture. You can buy even bigger binoculars, but a 50mm model is a good compromise between aperture and the cost, size, and weight of giant 60 to 80mm binoculars.

Even so, any binocular will provide sharper, clearer views when fastened to a tripod. Having a tripod socket built into the binocular body makes this much easier. (You'll need to buy an L-shaped binocular-to-tripod adapter bracket.)

Most binoculars feature a central focus knob that can adjust both eyepieces at once. This is by far the most convenient to use. Some waterproof marine binoculars have individual focus eyepieces — changing focus requires adjusting two eyepieces. For strictly astronomical use, this works fine. Because everything in the sky is effectively at infinity you should rarely need to make any focus adjustments.

A good pair of 7x50 or 10x50 binoculars might cost between $100 to $200, much less than the cost of a good starter telescope. First-time buyers often fret about the difference between 7x and 10x models. The lower power binoculars provide a wider field of view, making it easier to locate objects. It is also easier to hold 7x binoculars steady. Higher power 10x models resolve small clusters better, provided you hold them steady. But either will produce superb views.

Binoculars also vary in field of view. Most 7x50 models show about 7° of sky while the higher power of most 10x50 models results in a smaller 5° to 6° field. But some 10x50 binoculars (and other models) feature wide-angle eyepieces that provide a 7° or larger field. The view is impressive but most wide-angle models sacrifice image quality — stars at the edge of the field look distorted.

The 7x50 model has long been considered the classic "night glass." The reason is that it yields a 7mm exit pupil. This refers to the beam of light leaving the eyepiece and entering your eye. (To calculate exit pupil, simply divide the aperture by the magnification, 50 ÷ 7 in this case.)

An exit pupil 7mm wide matches the diameter of the pupil of a dark-adapted eye, making maximum use of the eye's and binocular's light-gathering abilities. You see the brightest image possible, if your eyes are fully dark adapted. And if you are young.

After age 30 your eyes no longer open as wide at night. By age 50 most people's eyes open no wider than 5mm. In this case, you can't take in all the light a 7x50 binocular can throw at you. The 50mm model effectively behaves like a 35 or 40mm binocular. But with the weight of a 50.

Jonathan Sabin

Following this logic, the best astronomy binoculars for aging baby boomers and retiring astronomers are probably 7x42 models (with a 6mm exit pupil) or 8x42 or 10x50 models (both yield a 5mm exit pupil).

Binoculars for Astronomy

Manufacturer	Model	Actual FOV (°)	Apparent FOV (°)	Eye Relief (mm)	Coatings	Prism Type	Focus Type	Roll Down Cups	Tripod Socket	Armored	Water-proof	Case	Warranty (years)	Weight (oz.)	Retail
7x42 MODELS															
Vivitar	Series 1	6.4	45	18	FMC	BaK4	CF	√	—	√	—	SV	30	22	$150
Carton	Adlerblick	6.5	46	22	FMC	BaK4	CF	√	√	partial	—	HV	20	21	$180
Tasco	Futura LE	7.0	49	18	C	BK7	CF	√	—	√	—	SV	Life	22	$216
Fujinon	Series 4000 DCF	6.5	46	21	MC	Roof	CF	√	√	—	—	incl.	Life	19	$230
Simmons	Euro-Deluxe	6.4	45	5	MC	BK7	CF	√	—	√	—	SV	Life	22	$230
Simmons	Master Guide	6.4	45	5	FMC	BaK4	CF	√	—	√	—	SV	Life	22	$289
Mirador	ZCFY-Series	6.6		22	MC	Bak4	CF	√	√	—	—	HV	Life	22	$378
Brunton	Eterna	9.4	66	22	FMC	BaK4	CF	√	√	√	√	SV	Life	28	$395
Swift	Ultralite ZCF	6.5	46	17	MC	BaK4	CF	√	√	partial	—	SV	Life	20	$400
Optolyth	Alpin	6.6	46	16	FMC	BaK4	CF	√	—	√	—	SL	30	17	$460
Swarovski	Traditional	6.5	46	12	FMC	BaK4	CF	√	—	option	√	—	Life	23	$550
Optolyth	Touring	8.0	56	10	FMC	Roof	CF	√	—	√	—	SL	30	30	$730
Swarovski	SLC	8.0	56	n/a	FMC	Roof	CF	√	√	√	√	—	Life	31	$990
Zeiss	B/GA T* Dialyt	8.6	60	19	FMC	Roof	CF	√	—	√	√	SL	30	28	$1,215
Leica	BA Ultra	8.0	56	17	FMC	Roof	CF	√	—	√	√	SL	Life	31	$1,299
Celestron	Ultima	7.0	49	23	FMC	BaK4	CF	√	√	partial	—	SV	Life	20	call
8x42 MODELS															
Orion	WA Ultraview	8.2	66	22	FMC	BaK4	CF	√	√	√	—	HV	10	27	$159
Carton	Adlerblick	6.3	50	18	FMC	BaK4	CF	√	√	partial	—	HV	20	21	$180
Bushnell	Spectator	6.5	52	12	C	Roof	CF	√	—	√	—	incl.	Life	22	$200
Orion	Vista	6.5	52	18	FMC	BaK4	CF	√	√	—	—	HV	20	22	$219
Parks	DCF	6.5	52	n/a	MC	Roof	CF	√	—	√	—	SV	Life	n/a	$279
Swift	Hawk HCF	6.5	52	16	MC	Roof	CF	√	—	√	—	SV	Life	18	$345
Mirador	ZCFY-Series	6.3		16	MC	BaK4	CF	√	√	—	—	HV	Life	22	$396
Swift	Ultralite ZCF	6.3	50	16	MC	BaK4	CF	√	√	partial	—	SV	Life	20	$410
Simmons	Presidential	n/a	n/a	5	FMC	BaK4	CF	√	—	√	—	SV	Life	26	$400
Pentax	DCF HR	6.2	50	22	FMC	Roof	CF	√	√	√	√	SL	Life	26	$440
Bausch&Lomb	PC Elite RA	7.0	56	18	FMC	Roof	CF	√	—	√	—	incl.	Life	30	$920
Leica	BA Ultra	7.4	59	16	FMC	Roof	CF	√	—	√	√	SL	Life	31	$1,299
OTHER 40mm-CLASS MODELS															
Celestron	6.5x44 ED Series	7.3	47	20	FMC	BaK4	CF	√	√	√	—	SV	Life	26	call
Swift	8.5x44 Audubon	8.2	70	12	MC	BaK4	CF	√	√	—	—	SV	Life	21	$495
Swift	8.5x44 ED Audubon	8.2	70	12	FMC	BaK4	CF	√	√	—	partial	SV	Life	n/a	$940
Celestron	9.5x44 ED Series	6.0	57	16	FMC	BaK4	CF	√	√	√	—	SV	Life	26	call
Zeiss	7x45B Design Select	8.6	60	17.7	FMC	Roof	CF	√	—	√	√	SL	30	42	$1,410
7x50 MODELS															
Simmons	Red Line	7.0	49	5	FC	BK7	CF	√	—	—	—	SV	Life	25	$72
Swift	Aerolite ZCF	7.1	50	14	C	BK7	CF	√	—	—	—	SV	5	38	$99
Tasco	Standard	7.0	49	n/a	C	BK7	CF	√	—	—	—	—	Life	27	$107
Bushnell	Ensign	7.0	49	n/a	C	BK7	CF	√	—	√	—	SV	Life	29	$120
Orion	Explorer	6.8	48	14	MC	BaK4	CF	√	—	partial	—	HV	5	25	$129
Nikon	Stayfocus Plus II	6.2	43	16	MC	BaK4	CF	√	—	partial	—	incl.	25	35	$130
Simmons	Euro-Platinum	7.1	50	5	MC	BK7	CF	√	—	√	—	SV	Life	30	$130
Swift	Swift Armord Aero.	8.0	56	17	C	BK7	CF	√	—	√	—	SV	5	32	$144
Parks	GR	7.1	50	n/a	MC	BaK4	CF	√	√	√	—	HV	Life	n/a	$149
Celestron	Pro	7.1	50	23	FMC	BaK4	CF	√	√	√	—	SV	Life	29	call
Tasco	Armored	7.0	49	n/a	C	BK7	CF	√	—	√	—	—	Life	33	$170
Mirador	BCF Series	7.2		n/a	C	BaK4	CF	√	√	—	—	HV	Life	25	$171
Orion	Ultraview	6.5	46	22	FMC	BaK4	CF	√	√	√	—	HV	10	32	$179
Vivitar	Series 1	7.1	50	15	FMC	BaK4	CF	√	√	√	√	SV	30	27	$180
Unitron	High Eyepoint	6.8	48	14	C	BK7	CF	√	—	partial	—	HV	25	25	$210
Swift	Dolphin ZCF	6.8	48	17	C	BK7	CF	√	√	partial	—	SV	Life	29	$215
Orion	Vista	6.0	42	22	FMC	BaK4	CF	√	√	—	—	HV	20	28	$219
Tasco	Futura LE	6.8	48	14	C	BK7	CF	√	—	√	—	SV	Life	25	$226
Pentax	PCF II	7.1	50	20	FMC	BaK4	CF	√	√	√	—	SL	Life	32	$244
Sigma	ZWCF Series 9000	7.1	n/a	18	MC	BaK4	CF	√	n/a	n/a	n/a	n/a	n/a	28	$240
Minolta	XL Standard	7.8	55	16	MC	BaK4	CF	√	√	√	—	HV	25	35	$251
Carton	MC Adlerblick	6.8	48	19	FMC	BaK4	CF	√	√	partial	—	HV	20	27	$280
Tasco	Waterproof	6.8	48	13	C	BaK4	IF	√	√	—	√	SV	Life	34	$290
Parks	Waterproof	7.1	50	18	MC	BaK4	CF	√	√	—	√	SV	Life	28	$299
Edmund	Waterproof Marine	7.5	53	n/a	C	BK7	CF	√	√	√	√	HV	1	37	$300
Swift	Sea Wolf BCF	6.8	48	16	C	BaK4	CF	√	√	√	√	—	Life	31	$320
Fujinon	MT-SX Poseidon	7.5	53	12	FMC	Porro BK4	IF	√	√	—	√	HV	Life	45	$680

Binoculars for Astronomy

Manufacturer	Model	Actual FOV (°)	Apparent FOV (°)	Eye Relief (mm)	Coatings	Prism Type	Focus Type	Roll Down Cups	Tripod Socket	Armored	Water-proof	Case	Warranty (years)	Weight (oz.)	Retail
7x50 MODELS *(cont.)*															
Swift	Sea Hawk BIF	7.3	51	13	C	BaK4	IF	√	√	√	√	—	Life	40	$395
Bushnell	Marine	7.3	51	12	C	BaK4	IF	√	√	√	√	SV	Life	39	$420
Minolta	Weathermatic	7.1	50	16	MC	BaK4	CF	√	√	√	√	HV	25	33	$440
Nikon	Seafarer II	7.3	51	15	FMC	BaK4	IF	√	—	√	√	—	25	61	$450
Optolyth	Alpin	5.8	41	22	FMC	BaK4	CF	√	—	√	—	SL	30	23	$490
Fujinon	AR Nautilus	7.5	53	16	FMC	Porro BK4	IF	√	√	√	√	opt.	Life	46	$490
Swift	Sea King	7.0	49	18	C	BaK4	CF	√	√	√	—	SV	Life	n/a	$525
Mirador	BCF Exc-Series	7.3		13	MC	BaK4	CF	√	√	—	—	incl.	Life	46	$549
Steiner	Admiral Gold	7.0	49	21	FMC	BaK4	IF	√	option	√	√	option	30	37	$700
From Jena	Nobilem	7.5	53	17	FMC	BaK4	CF	√	√	option	partial	HL	Life	37	$740
Nikon	IF-SP Prostar	7.3	51	15	FMC	BaK4	IF	√	—	—	√	HV	25	52	$750
From Jena	8x50B Nobilem	7.2	58	10	FMC	BaK4	CF	√	√	option	partial	HL	Life	37	$755
Fujinon	FMT-SX Polaris	7.5	53	23	FMC	Porro BK4	IF	√	√	—	√	HV	Life	52	$880
From Jena	Binoctar	7.3	51	n/a	FMC	BaK4	CF	√	√	option	—	HL	Life	35	$883
Swarovski	SL Series	6.7	47	11	FMC	BaK4	CF	√	—	√	√	—	Life	41	$930
Pentax	PIF	7.3	51	20	FMC	BaK4	IF	√	√	√	√	SL	Life	56	$960
Tasco	Waterproof	7.3	51	n/a	C	BaK4	IF	√	√	√	√	—	Life	52	$993
Optolyth	Royal	7.7	54	10	FMC	Roof	CF	√	—	√	—	HL	30	36	$1,300
Zeiss	B Marine	7.6	53	13	FMC	BaK4	IF	√	—	√	√	—	30	42	$1,760
Celestron	Ultima	7.0	49	20	FMC	BaK4	CF	√	√	partial	—	SV	Life	27	call
10x50 MODELS															
Simmons	WA Red Line	7.0	70	5	FC	BK7	CF	√	—	—	—	SV	Life	26	$72
Bushnell	Ensign	5.3	53	12	C	BK7	CF	√	—	—	—	incl.	Life	32	$90
Simmons	Euro-Style WA	7.0	70	5	FC	BK7	CF	√	—	—	—	SV	Life	28	$90
Swift	Aerolite ZCF	7.0	70	10	C	BK7	CF	√	—	—	—	SV	5	27	$103
Tasco	Wide Angle	7.0	70	n/a	C	BK7	CF	√	—	—	—	—	Life	26	$107
Orion	Explorer	5.3	53	14	FC & MC	BaK4	CF	√	—	partial	—	HV	5	26	$127
Bushnell	Camo Armored	7.0	70	12	C	BK7	CF	√	—	√	—	incl.	Life	29	$130
Nikon	Lookout III	6.0	60	9	MC	BaK4	CF	√	—	—	—	incl.	25	33	$130
Simmons	Euro-Deluxe WA	7.0	70	5	MC	BK7	CF	√	—	√	—	SV	Life	30	$130
Nikon	Stayfocus Plus II	6.0	60	9	MC	BaK4	CF	√	—	partial	—	incl.	25	34	$140
Parks	GR	6.0	60	n/a	MC	BaK4	CF	√	√	√	—	HV	Life	n/a	$140
Bausch&Lomb	Legacy EWA	7.9	79	10	MC	BaK4	CF	√	√	partial	—	incl.	Life	35	$149
Celestron	WA Pro	6.5	65	15	FMC	BaK4	CF	√	√	√	—	SV	Life	30	call
Bushnell	Spectator	7.0	70	12	C	BK7	CF	√	—	√	—	incl.	Life	26	$160
Orion	WA Ultraview	6.5	65	22	FMC	BaK4	CF	√	√	√	—	HV	10	32	$169
Mirador	BCF Series	7.0	n/a	n/a	C	BaK4	CF	√	√	—	—	HV	Life	25	$171
Unitron	High Eyepoint	5.3	53	14	C	BK7	CF	√	—	partial	—	HV	25	26	$210
Swift	Cougar ZWCF	7.0	70	13	C	BK7	CF	√	√	partial	—	SV	Life	29	$215
Orion	Vista	5.3	53	16	FMC	BaK4	CF	√	√	—	—	HV	20	28	$219
Bushnell	GlassesOn	6.5	65	17	C	BK7	CF	—		√	—	SV	Life	35	$220
Pentax	PCF II	6.5	65	14	FMC	BaK4	CF	√	√	√	—	SL	Life	32	$250
Tasco	Futura LE	5.3	53	18	C	BK7	CF	√	—	√	—	SV	Life	26	$255
Minolta	XL Standard	6.5	65	20	MC	BaK4	CF	√	√	√	—	HV	25	35	$264
Carton	MC Adlerblick	5.0	50	18	FMC	BaK4	CF	√	√	partial	—	HV	20	24	$270
Simmons	Master Guide	6.9	69	5	FMC	BaK4	CF	√	—	√	—	SV	Life	30	$289
Redfield	Waterproof	5.0	50	12	FMC	Roof	CF	√	—	√	√	SV	Life	29	$325
Brunton	Eterna	6.5	65	21	FMC	BaK4	CF	√	√	√	√	SV	Life	33	$406
Mirador	ZCFY-Series	5.0	n/a	16	MC	BaK4	CF	√	√	—	—	HV	Life	26	$405
Swift	Audubon BWCF	7.0	70	10	MC	BaK4	CF	√	√	—	—	SV	Life	32	$475
Optolyth	Alpin	5.1	51	16	FMC	BaK4	CF	√	—	√	—	SL	30	24	$500
Mirador	BWCF Exc-Series	7.0	n/a	13	MC	BaK4	CF	√	√	—	—	incl.	Life	46	$585
From Jena	WA Dekaris	7.3	73	n/a	FMC	BaK4	CF	√	√	option	—	HL	Life	36	$610
Steiner	Senator	6.2	62	17	FMC	BaK4	IF	—	option	√	√	—	30	36	$700
Swarovski	SL Series	5.8	58	5	FMC	BaK4	CF	√	—	√	√	—	Life	36	$1,000
Pentax	PIF	6.5	65	15	FMC	BaK4	IF	√	√	√	√	SL	Life	56	$1,000
Celestron	Ultima	5.0	50	21	FMC	BaK4	CF	√	√	partial	—	SV	Life	27	call
56mm and 60mm MODELS															
Orion	8x56 Mini-Giant	6.0	48	18	MC	BaK4	CF	√	√	option	—	HV	5	33	$159
Pentax	8x56 DCF	6.5	52	21	FMC	Roof	CF	√	√	√	√	SL	Life	41	$710
Steiner	8x56 Hunting	6.6	53	21	FMC	BaK4	IF	√	option	√	√	opt.	30	41	$800
From Jena	8x56W	6.7	54	16	FMC	BaK4	CF	√	√	—	partial	HL	Life	44	$895
Swarovski	8x56 SL Series	5.8	46	11	FMC	BaK4	CF	√	—	√	√	—	Life	43	$1,000
From Jena	10x60W	5.8	58	n/a	FMC	BaK4	CF	√	√	—	partial	HL	Life	39	$1,075
Optolyth	8x56 Royal	6.7	54	10	FMC	Roof	CF	√	—	√	—	HL	30	39	$1,230
Zeiss	8x56 T* Dialyt	6.3	50	19	FMC	Roof	CF	√	—	√	√	incl.	30	36	$1,565

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From Jena, c/o Europtik, Ltd., P.O. Box 319, Dunmore, PA 18512, (717) 347-6049.

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Leica Camera Group, 156 Ludlow Avenue, Northvale, NJ 07647, (201) 767-7500.

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Orion Telescope Center, 2450 17th Avenue, P.O. Box 1158, Santa Cruz, CA 95061, (800) 447-1001.

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Binoculars for Astronomy

Manufacturer	Model	Actual FOV (°)	Apparent FOV (°)	Eye Relief (mm)	Coatings	Prism Type	Focus Type	Roll Down Cups	Tripod Socket	Armored	Water-proof	Case	Warranty (years)	Weight (oz.)	Retail
56mm and 60mm MODELS *(cont.)*															
Zeiss	8x56B Select.	7.5	60	17.7	FMC	Roof	CF	√	—	√	√	SL	30	52	$1,565
Zeiss	10x56B Select	6.3	63	16	FMC	Roof	CF	√	—	√	√	SL	30	50	$1,700
Celestron	8x56 Pro	5.8	46	22	FMC	BaK4	CF	√	√	√	—	SV	Life	34	call
Celestron	8x56 Ultima	6.1	49	21	FMC	BaK4	CF	√	√	partial	—	HV	Life	31	call
9x63 MODELS															
Pentax	DCF	5.8	52	21	FMC	Roof	CF	√	√	√	√	SL	Life	44	$780
Optolyth	Royal	6.1	55	10	FMC	Roof	CF	√	—	√	—	HL	30	42	$1,435
Celestron	Pro	5.0	45	21	FMC	BaK4	CF	√	√	√	—	SV	Life	37	call
70mm MODELS															
Orion	14x70 MC Enhanced	4.0	56	17	FMC	BaK4	CF	√	√	—	—	HV	5	58	$288
Orion	10x70 MC Giant	5.0	50	15	FMC	BaK4	CF	√	√	—	—	HV	5	58	$369
Fujinon	10x70 Poseidon	5.3	53	12	FMC	Porro BK4	IF	√	√	—	√	HV	Life	73	$840
Fujinon	10x70 Polaris	5.3	53	23	FMC	Porro BK4	IF	√	√	—	√	HV	Life	76	$1,080
Fujinon	16x70 Polaris	4.0	64	12	FMC	Porro BK4	IF	√	√	—	√	HV	Life	76	$1,150
Unitron	10x70 Giant	5.0	50	n/a	C	BaK4	IF	√	√	—	√	incl.	25	50	$1,200
Nikon	10x70 Astroluxe	5.1	51	15	FMC	BaK4	IF	√	—	—	√	HV	25	88	$1,200
12 and 11x80 MODELS															
Orion	MC Giant	4.5	50	16	FMC	BaK4	CF	√	√	—	—	HV	5	77	$469
Parks	Deluxe Giant	4.5	50	20	FMC	BAk4	CF	√	√	√	—	HV	Life	80	$479
Unitron	Giant Observation	4.5	50	n/a	C	BaK4	CF	√	√	—	—	incl.	25	56	$715
Mirador	BCF Observation	4.5	n/a	n/a	MC	BaK4	CF	√	√	—	—	HV	Life	61	$612
Swift	Observer BCF	4.5	50	16	C	BaK4	CF	√	√	—	—	HV	Life	78	$665
Bausch&Lomb	Discoverer	4.4	48	12	MC	BaK4	CF	√	√	—	—	incl.	Life	80	$730
From Jena	11x80W	4.6	51	n/a	FMC	BaK4	CF	√	√	—	partial	HL	Life	58	$1,425
Celestron	12x80 Giant	4.5	50	18	FMC	BaK4	CF	√	√	—	—	HV	Life	89	call
15 and 16x80 MODELS															
Orion	16x80 MC Giant	3.5	56	16	FMC	BaK4	CF	√	√	—	—	HV	5	77	$469
Parks	15x80 Deluxe Giant	3.5	53	17	FMC	BaK4	CF	√	√	√	—	HV	Life	80	$499
Steiner	15x80 Senator	3.7	55	11	FMC	BaK4	IF	√	√	√	√	option	30	56	$1,100
From Jena	15x80W	4.3	64	n/a	FMC	BaK4	CF	√	√	—	partial	HL	Life	58	$1,475
Fujinon	15x80 MT	4.0	60	15	FMC	Porro BK4	IF	—	√	—	√	HV	Life	248	$3,700
20x80 MODELS															
Orion	MC Giant	3.5	70	15	FMC	BaK4	CF	√	√	—	—	HV	5	77	$469
Parks	Deluxe Giant	3.5	70	16	FMC	BaK4	CF	√	√	√	—	HV	Life	80	$539
Swift	Satellite	3.5	70	14	C	BaK4	CF	√	√	—	—	HV	Life	80	$695
Unitron	Giant	3.5	70	n/a	C	BaK4	CF	√	√	—	—	incl.	25	56	$730
Bausch&Lomb	Discoverer	2.7	54	12	MC	BaK4	CF	√	√	—	—	incl.	Life	80	$760
Miyauchi	20x77 Model	2.5	50	27	FMC	BaK4	IF	√	√	—	partial	option	Life	158	$1,072
From Jena	22x80W	3.2	70	n/a	FMC	BaK4	CF	√	√	—	partial	HL	Life	60	$1,475
Celestron	Giant	3.5	70	16	FMC	BaK4	CF	√	√	—	—	HV	Life	89	call
100mm and larger MODELS															
Orion	14x100 BIF Supergiant	3.3	46	24	FMC	BaK4	IF	√	√	—	—	Metal	5	112	$1,299
Orion	25x100 Supergiant	2.6	65	10	FMC	BaK4	CF	√	√	—	—	Metal	5	120	$1,299
Miyauchi	20x100 BJ-100iA	2.5	50	27	FMC	BaK4	IF	√	√	—	partial	option	Life	171	$2,635
Tasco	20x100 Apochromatic	2.5	50	27	FMC	BaK4	IF	√	√	—	√	—	Life	208	$6,790
Edmund	25x100 Giant	2.6	65	n/a	C	BK7	CF	√	√	—	—	Metal	1	140	$1,775
Parks	25x100 BWCF	2.5	63	n/a	FMC	BaK4	CF	√	√	—	—	incl.	Life	208	$1,999
Fujinon	25x150 MT	2.7	67	18	FMC	Porro BK4	IF	—	√	—	√	opt.	Life	1,000	$6,600
Fujinon	25x150 ED-MT	2.7	67	18	FMC	Porro BK4	IF	—	√	—	√	opt.	Life	1,000	$10,620

KEY:

Actual FOV	Actual field of view (in degrees).
Apparent FOV	Apparent field of view (in degrees).
Eye Relief	Distance eyes need to be back from the binocular to see the entire field (in millimeters).
Coatings	Type of optical coatings. C = single-layer; MC = some surfaces multicoated; FMC = all surfaces multicoated.
Prism Type	Either BK7 or BaK4 porro prisms, or roof prisms.
Focus Type	Either CF (center focus) or IF (individual focus).
Roll Down Cups	Rubber eye cups fold down to facilitate viewing with eyeglasses.
Tripod Socket	Model has ¼-20 threaded socket for attaching tripod adapter bracket.
Armored	Model is fully rubber armored. "Partial" indicates unit has soft covering over part of body; "option" indicates model is available in armored version.
Waterproof	Model is waterproof. "Partial" indicates model is water-resistant or splashproof.
Case	Model comes with a case. SV = soft vinyl; HV = hard vinyl; SL = soft leather; HL = hard leather.
Warranty	Model's warranty period (in years).
Weight	Body weight (in ounces).
Retail	Typical retail price, or suggested retail price as supplied by manufacturer. Actual prices at dealers may vary. Call = call manufacturer.

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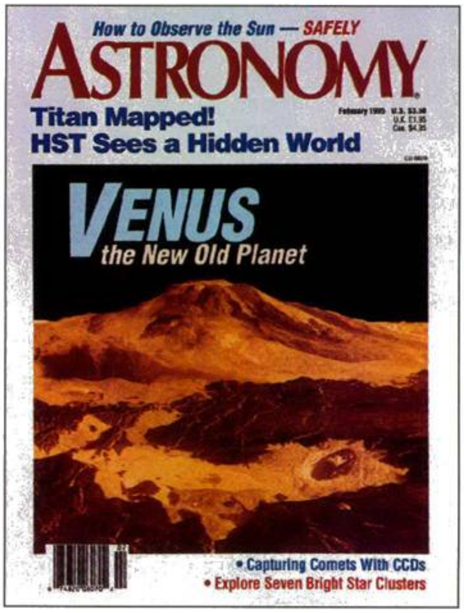
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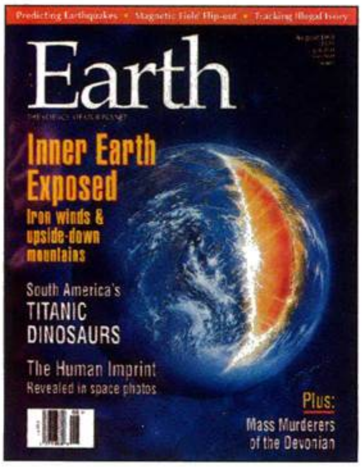
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Selecting a Set of Eyepieces

A good set of eyepieces makes telescope views sharp and exciting.

by Alan Dyer

Improving a telescope's performance isn't the only reason people buy additional eyepieces. Many telescopes often come with only one eyepiece as standard equipment. This leaves the owner with a telescope capable of providing only one magnification. A range of three magnifications (low, medium, and high) is essential for any backyard observer's telescope. This requires three interchangeable eyepieces. But which ones? There are hundreds on the market.

Low, Medium, and High

A good range of magnifications for most telescopes is 30x to 50x (for low power), 80x to 120x (for medium power), and 150x to 200x (for high power).

The low power eyepiece provides a wide field for locating and centering objects. Low power also provides the best view of large, bright objects such as the Pleiades star cluster and Milky Way starfields.

Medium power is where your telescope will spend most of its time. With any telescope with an aperture of 80mm or greater, 80x to 100x often gives the best view of smaller deep-sky objects such as globular clusters, many nebulae, and most galaxies. It's also terrific on the Moon and Jupiter.

High power is often reserved for the planets. High power also singles out craters and mountain ranges on the Moon. Some deep-sky objects also stand out best under high-power scrutiny.

Unfortunately, no eyepiece is marked with a magnification. Instead, eyepieces are marked with their focal lengths, usually indicated in millimeters. You don't buy a "100x" eyepiece, you buy a 10mm eyepiece, or a 20mm eyepiece. A given eyepiece will produce different magnifications on different telescopes. So there can be no such thing as a universal 100x eyepiece.

How much power an eyepiece will produce on a telescope depends on the focal length of that telescope. The focal length, usually given in millimeters, is often marked on the telescope or listed in the instruction manual. It's easy to figure out the magnification of a particular eyepiece-telescope combination: simply divide the focal length of the telescope by the focal length of the eyepiece.

Say you have a 2,000mm-focal length telescope (an 8-inch f/10 Schmidt-Cassegrain, for example). A 20mm eyepiece would yield 100x (2000mm ÷ 20mm = 100x), a good all-purpose medium power. To achieve a high-

Telescope Eyepieces

Brand	Series	Focal Length	Apparent FOV (°)	Coatings	Eye Relief (mm)	Eyecups	Parfocal	Retail
Standard Field of View — 0.965-inch Barrel								
Celestron	Kellner	40	35	C	25	—	—	call
Celestron	Kellner	30	40	C	20	—	—	call
Celestron	Kellner	25	42	C	16	—	—	call
Celestron	Kellner	18	42	C	12	—	—	call
Celestron	Kellner	10	43	C	9	—	—	call
Celestron	Plössl	26	50	MC	22	—	√	call
Celestron	Plössl	17	52	MC	13	—	√	call
Celestron	Plössl	10	52	MC	6.5	—	√	call
Celestron	Plössl	7.5	52	MC	5	—	√	call
Edmund	Kellner	25	39	C	n/a	—	—	$49
Edmund	Kellner	18	46	C	n/a	—	—	$49
Edmund	Kellner	12	38	C	n/a	—	—	$49
Edmund	Kellner	9	45	C	n/a	—	—	$49
Edmund	Kellner	6	40	C	n/a	—	—	$49
Edmund	Orthoscopic	25	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	18	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	12.5	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	6	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	4	n/a	C	n/a	—	—	$70
Meade	Modified Achr.	40	36	C	18	—	—	$29
Meade	Modified Achr.	25	40	C	16	—	—	$29
Meade	Modified Achr.			12	40	C	8	—
—	$29							
Meade	Modified Achr.	9	40	C	6	—	—	$29
Orion	Achr. Huygenian	40	30	MC	14	—	—	$39.95
Orion	Kellner	25	38	MC	15	—	—	$39.95
Orion	Kellner	18	38	MC	10	—	—	$39.95
Orion	Orthoscopic	12.5	40	MC	9	—	—	$54.95

KEY

Series	Generic optical design or manufacturer's brand name.
Focal length	Focus in millimeters.
Apparent FOV	Apparent field of view (in degrees).
Coatings	Type of optical coatings. C = single-layer; MC = some surfaces multicoated; FMC = all surfaces multicoated.
Eye Relief	Distance your eye needs to be above the eyepiece to see the entire field (in millimeters).
Eyecups	Unit has rubber eyecups for blocking stray light.
Parfocal	Unit focuses at the same point as other eyepieces in the series.
Retail	Typical retail price, or suggested retail price as supplied by manufacturer. Actual prices at dealers may vary. Call = call manufacturer

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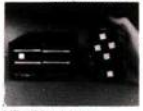

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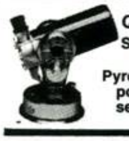

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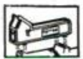

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Orion	Orthoscopic	7	44	MC	5	—	—	$54.95
Orion	Orthoscopic	5	44	MC	5	—	—	$54.95
Parks	.96 Series	22	32	C	n/a	—	—	$38
Parks	.96 Series	20	32	C	n/a	—	—	$38
Parks	.96 Series	12.5	32	C	n/a	—	—	$38
Parks	.96 Series	9	32	C	n/a	—	—	$38
Parks	.96 Series	6	32	C	n/a	—	—	$38
Parks	.96 Series	4	32	C	n/a	—	—	$38
Standard Field of View — 0.965-inch Barrel *(cont.)*								
Takahashi	NP12	12	n/a	FMC	n/a	—	—	$160
Takahashi	PJ120	20	n/a	FMC	n/a	—	—	$140
Tuthill	Orthoscopic	25	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	18	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	12.5	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	9	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	7	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	6	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	5	n/a	C	n/a	—	√	$55
Tuthill	Orthoscopic	4	n/a	C	n/a	—	√	$55
Standard Field of View — 1.25-inch Barrel								
Adorama	Pro-Optic Plössl	40	46	C	31	—	√	$70
Adorama	Pro-Optic Plössl	25	50	C	22	—	√	$42
Adorama	Pro-Optic Plössl	17	52	C	14	—	√	$42
Adorama	Pro-Optic Plössl	10	52	C	6.5	—	√	$42
Adorama	Pro-Optic Plössl	7.5	52	C	5	—	√	$42
Celestron	SMA	25	52	FC	14	—	√	call
Celestron	SMA	10	52	FC	5	—	—	call
Celestron	Plössl	40	46	MC	31	—	√	call
Celestron	Plössl	32	52	MC	22	—	√	call
Celestron	Plössl	26	50	MC	22	—	√	call
Celestron	Plössl	17	52	MC	13	—	√	call
Celestron	Plössl	12.5	52	MC	8	—	√	call
Celestron	Plössl	10	52	MC	6.5	—	√	call
Celestron	Plössl	7.5	52	MC	5	—	√	call
Celestron	Plössl	6.3	52	MC	5	—	√	call
Celestron	Ultima	42	36	FMC	32	√	—	call
Celestron	Ultima	35	49	FMC	25	√	—	call
Celestron	Ultima	30	50	FMC	21	√	√	call
Celestron	Ultima	24	51	FMC	18	√	√	call
Celestron	Ultima	18	51	FMC	13	√	√	call
Celestron	Ultima	12.5	51	FMC	9	√	√	call
Celestron	Ultima	7.5	51	FMC	5	√	√	call
Celestron	Ultima	5	50	FMC	4	√	√	call
Celestron	Ultima Zoom	6.5-18	var.	MC	11	—	√	call
Celestron	Vixen LV	25	50	FMC	20	√	√	call
Celestron	Vixen LV	20	50	FMC	20	√	√	call
Celestron	Vixen LV	15	50	FMC	20	√	√	call
Celestron	Vixen LV	10	50	FMC	20	√	√	call
Celestron	Vixen LV	9	50	FMC	20	√	√	call
Celestron	Vixen LV	6	45	FMC	20	√	√	call
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Celestron	Vixen LV	4	45	FMC	20	√	√	call
Celestron	Vixen LV	2.5	45	FMC	20	√	√	call
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Edmund	Kellner	18	46	C	n/a	—	—	$49
Edmund	Kellner	12	38	C	n/a	—	—	$49
Edmund	Kellner	9	45	C	n/a	—	—	$49
Edmund	Kellner	6	40	C	n/a	—	—	$49
Edmund	RKE	28.7	45	C	25	√	√	$50
Edmund	RKE	21.5	45	C	19	—	√	$50
Edmund	RKE	15	45	C	13	—	√	$50
Edmund	RKE	12	45	C	11	—	√	$50
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Edmund	Orthoscopic	25	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	18	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	12.5	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	6	n/a	C	n/a	—	—	$70
Edmund	Orthoscopic	4	n/a	C	n/a	—	—	$70
Masuyama	Masuyama	35	52	FMC	n/a	—	√	n/a
Masuyama	Masuyama	30	52	FMC	n/a	—	√	n/a
Masuyama	Masuyama	25	52	FMC	n/a	—	√	n/a

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"The LUMICON O-III proved to be our favorite... It gave the greatest contrast gain."
***ASTRONOMY*, February 1991**

AMAZING O-III FILTER™

Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.

GREATLY ENHANCED DETAIL

"Consistently performed well on all emssion and planetary nebulae. Detail and structure were greatly enhanced in the more than two dozen objects I viewed." ***SKY & TELESCOPE*, July 1995**

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"From my light polluted backyard, the view ... was better with the O-III than with any other filter tested. The view was even better than without the filter from a dark-sky site." ***SKY & TELESCOPE*, July 1995**

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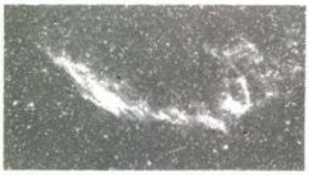
*"**LUMICON's H-Beta Filter** will show subtle features in emission nebulae that the others fail to reveal. It can't be beat for the elusive Horsehead and California nebulae. . ."* ***SKY & TELESCOPE*, July 1995**



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Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Rich Zepernick, Cresskill, NJ

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*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complementary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."* ***ASTRONOMY*, February 1991**

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†U.S. Patent 4,473,636

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Full aperture. Installs in seconds. Specify 2" or 1¼".

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Pentax 6X7 **add $119;** Pentax 645 **add $139**

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For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

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For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

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Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

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Scotch
1000
TP 135-36

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Fuji HG400 fine grain color neg.	12	**$14.95**
Ektachrome 1600, fast slide film	24	**$14.95**
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Color band - white. Class "B" filters are made with polished glass and multi-alloy coating. These filters offer great durability and will provide many years of service and enjoyment with normal use. Can be used visually and for photography. Light transmission is 1/1000th of 1%.

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Color band - red. Class "C" filters are specifically coated to a lighter density (ND-4). They are for photographic use only. This filter is intended for use by professionals and serious hobbyists. Light transmission is 1/100th of 1%.

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2.0"-2.4"	$57.00	$42.00	$75.00
2.5"-3.4"	60.00	46.00	78.00
3.5"-4.5"	70.00	52.00	92.00
4.6"-5.5"	90.00	67.00	117.00
5.6"-6.5"	97.00	72.00	127.00
6.6"-8.5"	117.00	87.00	152.00
8.6"-10.5"	127.00	97.00	166.00
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1. State scope brand and model number, aperture and outside diameter with filter class and price.
2. Make check or money order payable to **J.M.B. Inc.** All foreign checks must be payable through a U.S. bank.
3. Shipped free within the continental United States. All others add $5.50 Shipping and Handling per filter. Michigan residents add 4% sales tax, allow 2-3 weeks for delivery.

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Brand	Series	Focal Length	Apparent FOV (°)	Coatings	Eye Relief (mm)	Eyecups	Parfocal	Retail
Masuyama	Masuyama	20	52	FMC	n/a	—	√	n/a
Masuyama	Masuyama	15	52	FMC	n/a	—	√	n/a
Masuyama	Masuyama	10	52	FMC	n/a	—	√	n/a
Masuyama	Masuyama	7.5	52	FMC	n/a	—	√	n/a
Meade	Modified Achr.	40	36	MC	18	—	—	$37.95
Meade	Modified Achr.	25	40	MC	16	—	—	$37.95
Meade	Modified Achr.	12	40	MC	8	—	—	$37.95
Meade	Modified Achr.	9	40	MC	6	—	—	$37.95
Standard Field of View — 1.25-inch Barrel *(cont.)*								
Meade	3000 Plössl	40	44	MC	29	—	√	$80
Meade	3000 Plössl	25	50	MC	16	—	√	$50
Meade	3000 Plössl	16	50	MC	10	—	√	$50
Meade	3000 Plössl	9.5	50	MC	6	—	√	$50
Meade	3000 Plössl	6.7	50	MC	4	—	√	$50
Meade	3000 Plössl	5	50	MC	3	—	√	$50
Meade	4000 Super Plössl	40	44	FMC	30	√	—	$110
Meade	4000 Super Plössl	32	52	FMC	20	√	√	$110
Meade	4000 Super Plössl	26	52	FMC	18	√	√	$88
Meade	4000 Super Plössl	20	52	FMC	13	√	√	$88
Meade	4000 Super Plössl	15	52	FMC	9	√	√	$88
Meade	4000 Super Plössl	12.4	52	FMC	7	√	√	$88
Meade	4000 Super Plössl	9.7	52	FMC	5	√	√	$88
Meade	4000 Super Plössl	6.4	52	FMC	2	√	√	$88
Orion	Kellner	40	30	MC	14	—	√	$49.95
Orion	Kellner	25	40	MC	20	—	√	$49.95
Orion	Kellner	18	54	MC	15	—	√	$49.95
Orion	Kellner	12	40	MC	9	—	√	$49.95
Orion	Kellner	9	40	MC	7	—	√	$49.95
Orion	Kellner	6	40	MC	5	—	√	$49.95
Orion	Orthoscopic	25	41	MC	20	—	√	$59.95
Orion	Orthoscopic	18	45	MC	14	—	√	$59.95
Orion	Orthoscopic	12.5	40	MC	12	—	√	$59.95
Orion	Orthoscopic	9	44	MC	6	—	√	$59.95
Orion	Orthoscopic	7	44	MC	6	—	√	$59.95
Orion	Orthoscopic	5	44	MC	5	—	√	$59.95
Orion	Sirius Plössl	40	43	C	22	√	√	$79.95
Orion	Sirius Plössl	26	50	C	20	√	√	$59.95
Orion	Sirius Plössl	17	50	C	13	√	√	$59.95
Orion	Sirius Plössl	10	50	C	7	√	√	$59.95
Orion	Sirius Plössl	7.5	50	C	5	√	√	$59.95
Orion	Ultrascopic	35	49	FMC	25	√	—	$149
Orion	Ultrascopic	30	52	FMC	21	√	√	$129
Orion	Ultrascopic	25	52	FMC	17	√	√	$109
Orion	Ultrascopic	20	52	FMC	13	√	√	$95
Orion	Ultrascopic	15	52	FMC	10	√	√	$95
Orion	Ultrascopic	10	52	FMC	6	√	√	$95
Orion	Ultrascopic	7.5	52	FMC	5	√	√	$95
Orion	Ultrascopic	5	52	FMC	8	√	√	$95
Orion	Ultrascopic	3.8	52	FMC	6	√	√	$95
Parks	Kellner	40	32	MC	n/a	—	—	$45
Parks	Kellner	25	42	MC	n/a	—	—	$45
Parks	Kellner	12	42	MC	n/a	—	—	$45
Parks	Kellner	6	42	MC	n/a	—	—	$45
Parks	Gold Plössl	35	50	MC	25	—	—	$163
Parks	Gold Plössl	30	52	MC	21	—	√	$130
Parks	Gold Plössl	25	52	MC	17	—	√	$98
Parks	Gold Plössl	20	52	MC	13	—	√	$98
Parks	Gold Plössl	15	52	MC	10	—	√	$91
Parks	Gold Plössl	10	52	MC	6	—	√	$91
Parks	Gold Plössl	7.5	52	MC	5	—	√	$91
Parks	Gold Plössl	5	52	MC	8	—	√	$156
Parks	Gold Plössl	3.8	52	MC	6	—	√	$156
Takahashi	LE-MC	30	50	FMC	20	√	√	$185.50
Takahashi	LE-MC	24	50	FMC	17	√	√	$163.50
Takahashi	LE-MC	18	50	FMC	13	√	√	$163.50
Takahashi	LE-MC	12.5	50	FMC	9	√	√	$163.50
Takahashi	LE-ED/MC	7.5	50	FMC	10	√	√	$174.50
Takahashi	LE-ED/MC	5	50	FMC	10	√	√	$174.50
Tele Vue	Plössl	40	43	FMC	28	√	—	$107
Tele Vue	Plössl	32	50	FMC	22	√	√	$107
Tele Vue	Plössl	26	50	FMC	18	√	√	$80
Tele Vue	Plössl	21	50	FMC	14	√	√	$80
Tele Vue	Plössl	17	50	FMC	12	√	√	$80

Telescope Eyepieces

Brand	Series	Focal Length	Apparent FOV (°)	Coatings	Eye Relief (mm)	Eyecups	Parfocal	Retail
Tele Vue	Plössl	13	50	FMC	9	√	√	$80
Tele Vue	Plössl	10.5	50	FMC	7	√	√	$80
Tele Vue	Plössl	7.4	50	FMC	5	√	√	$80
Tuthill	Orthoscopic	25	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	18	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	12.5	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	9	n/a	C	n/a	—	√	$65
Standard Field of View — 1.25-inch Barrel *(cont.)*								
Tuthill	Orthoscopic	7	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	6	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	5	n/a	C	n/a	—	√	$65
Tuthill	Orthoscopic	4	n/a	C	n/a	—	√	$65
Tuthill	Plössl	35	45	MC	25	—	√	$105
Tuthill	Plössl	30	50	MC	21	—	√	$89
Tuthill	Plössl	25	50	MC	17	—	√	$79
Tuthill	Plössl	20	50	MC	13	—	√	$79
Tuthill	Plössl	15	50	MC	10	—	√	$79
Tuthill	Plössl	10	50	MC	6	—	√	$79
Tuthill	Plössl	7.5	50	MC	5	—	√	$79
Tuthill	Plössl	5	50	MC	n/a	—	√	$79
University	König II	32	52	FMC	n/a	—	—	$115
University	Orthoscopic	25	45	MC	n/a	—	—	$49.95
University	Orthoscopic	18	45	MC	n/a	—	—	$49.95
University	Orthoscopic	12.5	45	MC	n/a	—	—	$49.95
University	Orthoscopic	9	45	MC	n/a	—	—	$49.95
University	Orthoscopic	25	45	MC	n/a	—	—	$49.95
University	Orthoscopic	7	45	MC	n/a	—	—	$49.95
University	Orthoscopic	5	45	MC	n/a	—	—	$49.95
University	Plössl	20	50	MC	n/a	—	—	$54.95
University	Plössl	12	50	MC	n/a	—	—	$54.95
University	Plössl	7	50	MC	n/a	—	—	$54.95
VernonScope	Brandon	32	50	C	26	√	√	$165

power of 200x you'd need a 10mm eyepiece. So a three-eyepiece set for this telescope might be a 40mm (50x), 20mm (100x), and 10mm (200x).

Although the actual magnifications vary from scope to scope, the general rule applies to all telescopes — the smaller the eyepiece focal length, the higher the power it produces.

Small, Medium, and Large

Now that you have magnification ranges and eyepiece focal lengths selected, the next step is determining what diameter eyepiece you need. Eyepieces come in three barrel sizes. One isn't necessarily better than the others, but buying an eyepiece that doesn't fit your telescope is definitely a problem.

Many imported telescopes accept only the smaller 0.965-inch-diameter eyepieces. The selection of eyepieces of this size is limited and the quality of many of these eyepieces offered as standard equipment is often quite poor.

The most common barrel size is 1.25 inches. As the tables attest, the market offers dozens of models to pick from. A set of at least three eyepieces of this size may be all you'll ever need.

Some eyepieces come in 2-inch barrels. The giant size allows for a wide field of view in long-focal length models. These are breathtaking "picture-window"

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eyepieces, but to use them you need a telescope with a focuser capable of accepting 2-inch accessories.

Good, Better, Best

Within a barrel-size family, not all eyepieces are equal. The principle variation is the optical design — the number of lens elements in the eyepiece and their shape and placement. Some designs are decades old and are offered by many manufacturers. More recent designs are proprietary to specific manufacturers, but often with similar units offered by competitors.

The simplest and therefore most economical eyepiece designs worth considering are the 3-element Kellners, Modified Achromats (from Meade), and RKE (from Edmund). A step up in quality, yielding a sharper, wider field, are the 4-element orthoscopic eyepieces. Many companies offer these.

Four-element Plössl eyepieces are

Telescope Eyepieces

Brand	Series	Focal Length	Apparent FOV (°)	Coatings	Eye Relief (mm)	Eyecups	Parfocal	Retail
VernonScope	Brandon	24	50	C	19	√	√	$165
VernonScope	Brandon	16	50	C	13	√	√	$165
VernonScope	Brandon	12	50	C	10	√	√	$165
VernonScope	Brandon	8	50	C	6	√	√	$165
Standard Field of View — 2-inch Barrel								
Masuyama	Masuyama	80.0	34	FMC	n/a	—	√	n/a
Masuyama	Masuyama	60.0	46	FMC	n/a	—	√	n/a
Masuyama	Masuyama	45.0	50	FMC	n/a	—	√	n/a
Meade	4000 Super Plössl	56.0	52	FMC	47	√	—	$230
Orion	Plössl	50.0	50	MC	20	—	—	$129
Parks	Plössl	50.0	51	MC	n/a	—	—	$150
Takahashi	LE-50 MC	50.0	50	FMC	n/a	√	—	$359
Tele Vue	Plössl	55.0	50	FMC	38	√	—	$220
VernonScope	Brandon	48.0	50	C	38	√	√	$295
Wide Angle — 1.25-inch Barrel								
Japanoptik	WideVue	25	65	FMC	n/a	—	√	n/a
Japanoptik	WideVue	17	65	FMC	n/a	—	√	n/a
Japanoptik	WideVue	12	65	FMC	n/a	—	√	n/a
Japanoptik	WideVue	9	65	FMC	n/a	—	√	n/a
Japanoptik	WideVue	7	65	FMC	n/a	—	√	n/a
Masuyama	Masuyama	25	65	FMC	n/a	—	√	n/a
Meade	4000 Super Wide	24.5	67	FMC	19	√	√	$200
Meade	4000 Super Wide	18	67	FMC	14	√	√	$170
Meade	4000 Super Wide	13.8	67	FMC	10	√	√	$160
Orion	MegaVista	16.8	67	FMC	16	√	√	$189
Wide Angle — 1.25-inch Barrel *(cont.)*								
Orion	MegaVista	10.5	67	FMC	13	√	√	$199
Tele Vue	Wide-Field	19	65	FMC	11	√	√	$150
Tele Vue	Wide-Field	15	65	FMC	9	√	√	$140
Tele Vue	Panoptic (1.25/2")	22	68	FMC	16	√	√	$250
Tele Vue	Panoptic	15	68	FMC	10	√	√	$200
University	König II	24	60	FMC	n/a	—	—	$99.95
University	König II	16	65	FMC	n/a	—	—	$79.95
University	König II	12	60	FMC	n/a	—	—	$79.95
University	König II	8	60	FMC	n/a	—	—	$79.95
University	König II	6.5	65	FMC	n/a	—	—	$79.95
Wide Angle — 2-inch Barrel								
Celestron	Vixen LV	30	60	FMC	20	√	√	Call
Japanoptik	WideVue	32	65	FMC	n/a	—	√	n/a
Meade	4000 Super Wide	40	67	FMC	27	√	—	$340
Meade	4000 Super Wide	32	67	FMC	20	√	—	$280
Orion	Erfle	32	65	MC	42	—	—	$139
Parks	Erfle	32	65	MC	n/a	—	—	$150
Tele Vue	Panoptic	35	68	FMC	25	√	√	$325
Tele Vue	Panoptic	27	68	FMC	18	√	√	$300
University	König II	32	60	FMC	n/a	—	—	$125
Extra Wide Angle — 1.25-inch Barrel								
Meade	4000 Ultra Wide	6.7	84	FMC	11	√	√	$220

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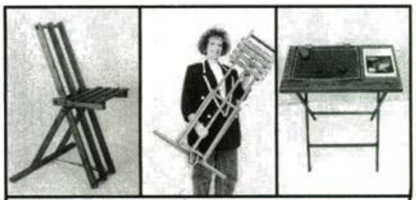
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Jean Dragesco

Telescope Eyepieces

Brand	Series	Focal Length	Apparent FOV (°)	Coatings	Eye Relief (mm)	Eyecups	Parfocal	Retail
Meade	4000 Ultra Wide	4.7	84	FMC	7	√	√	$180
Tele Vue	Nagler	7	82	FMC	10	√	√	$190
Tele Vue	Nagler	4.8	82	FMC	6	√	√	$150
Extra Wide Angle — Dual 1.25/2-inch Barrel								
Meade	4000 Ultra Wide	14	84	FMC	23	√	—	$330
Meade	4000 Ultra Wide	8.8	84	FMC	16	√	√	$270
Tele Vue	Nagler II	16	82	FMC	10	√	√	$290
Tele Vue	Nagler	13	82	FMC	18	√	√	$250
Tele Vue	Nagler II	12	82	FMC	11	√	√	$250
Tele Vue	Nagler	9	82	FMC	12	√	√	$220
Extra Wide Angle — 2-inch Barrel								
Tele Vue	Nagler II	20	82	FMC	12	√	√	$340

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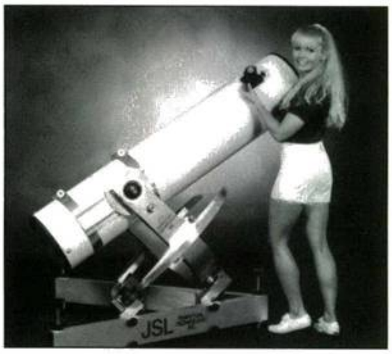

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Roger W. Tuthill, Inc., Box 1086, 11 Tanglewood Lane, Mountainside, NJ 07092, (908) 232-1786. ▮ ▣ ☉ ▬
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SkyComm Engineering, 4691 N. University Drive, Suite 329, Coral Springs, FL 33067, (305) 345-8726. ▬
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Space Technologies and Research, 700 Seminola Blvd., Casselberry, FL 32707. ▬
Spectra Astro Systems, 6631 Wilbur Ave., Suite 30, Reseda, CA 91335, (818) 343-1352. ▣
SpectraSource Instruments, 31324 Via Colinas, Suite 114, Westlake Village, CA 91362, (818) 707-2655. ▣
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Taurus Technologies, P.O. Box 14, Woodstown, NJ 08098, (609) 769-4509. ▣
Tele Vue Optics, Inc., 100 Route 59, Suffern, NY 10901, (914) 357-9522. ▮ ▣ ☉ ▬
Thousand Oaks Optical, Box 5044-289, Dept. A, Thousand Oaks, CA 91359, (805) 491-3642. ☉
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☉ Solar filters
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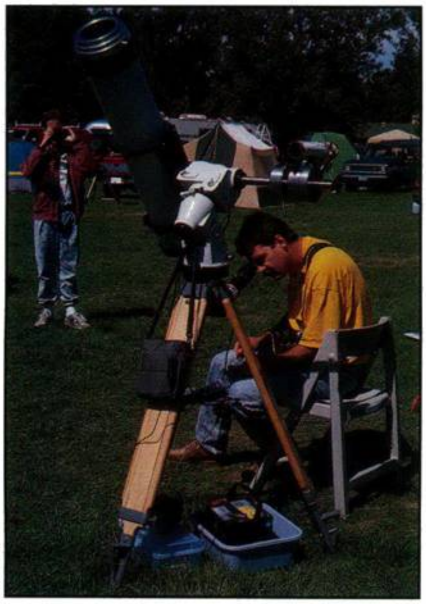

Alan Dyer

Avoid simple 2-element Huyghenian and Ramsden eyepieces and other odd designs such as Symmetrical Ramsden. Often supplied with low-cost import telescopes, these 0.965-inch eyepieces are marked with designations such as H12, HM6, and SR4. If your telescope has these, replacing them with a set of 0.965-inch Plössls or orthoscopics will make a world of difference in image quality.

Coated, Fully Coated, and Multicoated

All eyepieces, like camera lenses, feature anti-reflection coatings. Most are at least single-layer coated on all surfaces. But many eyepieces feature multi-layer coatings on some or all surfaces. Multicoatings reduce ghost images and increase light transmission.

To achieve high power without sacrificing eye relief, many amateurs turn to Barlow lenses. These insert between the eyepiece and focuser and effectively double or triple the power of any eyepiece. For example, a 10mm eyepiece with a 2x Barlow produces the same power as a 5mm eyepiece, but retains the comfortable eye relief of a 10mm eyepiece. With a complementary Barlow lens, your basic set of three eyepieces expands to give you six magnifications.

But choose your powers carefully — a 2x Barlow coupled with 20mm, 10mm, and 5mm eyepieces serves no purpose. With the Barlow, the 20mm eyepiece behaves like a 10mm, while the 10mm behaves like a 5mm, both of which you already have. The only new power comes from coupling the Barlow with the 5mm eyepiece, but this may yield too much power to be useful.

A final caveat — avoid cheap Barlow lenses. They only add false color and image-distorting aberrations. Plan to spend $80 to $120 for a good-quality Barlow.

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CharTable

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GLASS (Full Aperture) Type 1

Made from high quality hand select glass, machine polished and **TRIPLE COATED** with a Nickel-Chromium alloy. Mounted in a machined aluminum cell ready to attach to telescope. Solar image is yellow-orange. No secondary filtering is necessary.

Aperture	Mounted	Aperture	Unmounted
2.4"	$49.00	2.4"	$39.00
3.1"	52.00	3.1"	42.00
3.5" to 4"	59.00	3.5 to 4"	49.00
4-1/4" to 5"	74.00	4-1/4" to 5"	64.00
6"	79.00	6"	69.00
8"	95.00	8"	85.00
10"	109.00	10"	99.00
11"	119.00	11"	109.00
12.5" to 13.1"	149.00	12.5" to 13.1"	129.00
14"	169.00	14"	149.00

40mm to 80mm Binoculars - Mounted .... $92.00 pr.

GLASS (Full Aperture) Type 2

Same as type 1, except stainless steel is combined in the coating to provide an even more durable surface that highly resists wear due to excessive handling and ultraviolet radiation. Solar image is also yellow-orange.

Aperture	Mounted	Aperture	Unmounted
2.4"	$62.00	2.4"	$52.00
3.1"	65.00	3.1"	55.00
3.5" to 4"	76.00	3.5 to 4"	66.00
4-1/4" to 5"	96.00	4-1/4" to 5"	86.00
6"	105.00	6"	95.00
8"	125.00	8"	109.00
10"	139.00	10"	129.00
11"	149.00	11"	139.00
12.5" to 13.1"	179.00	12.5" to 13.1"	159.00
14"	199.00	14"	179.00

40mm to 80mm Binoculars - Mounted .... $115.00 pr.

GLASS (Full Aperture) Type 3

Coated to a neutral density of 4 for serious astrophotographers who desire the shortest possible shutter speeds with slow films. Solar image and optical quality same as type 1 & type 2. Type 3 filters are for photographic use only.

Aperture	Mounted	Aperture	Unmounted
2.4"	$79.00	2.4"	$65.00
3.1"	82.00	3.1"	69.00
3.5" to 4"	99.00	3.5 to 4"	79.00
4-1/4" to 5"	125.00	4-1/4" to 5"	110.00
6"	135.00	6"	115.00
8"	159.00	8"	139.00
10"	172.00	10"	152.00
11"	199.00	11"	179.00
12.5" to 13.1"	229.00	12.5" to 13.1"	209.00
14"	259.00	14"	239.00

Types 1 & 2 are for unlimited visual use and general photographic use. Instructions included with all filters, including tips on solar photography.

1/4 WAVE PREMIUM FILTERS

(Type 2 coating)

Aperture	Mounted	Aperture	Unmounted
2.4"	$129.00	2.4"	$119.00
3.1"	199.00	3.1"	189.00
3.5" to 4"	269.00	3.5 to 4"	259.00
5"	349.00	5"	339.00
6"	399.00	6"	389.00

Add $15.00 for Type 3 coating.

Please call or write for available sizes and pricing.

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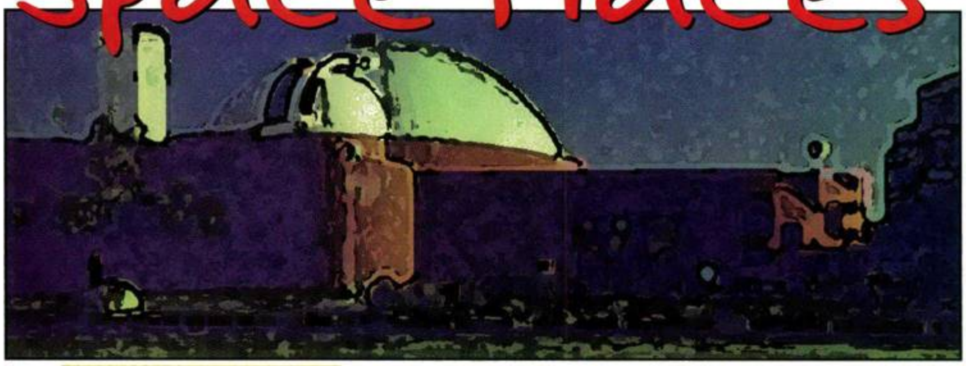

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Edmonton, Edmonton Space & Science Centre, 11211 - 142 Street, T5M 4A1, Frank Florian & Max Scharfenberger, (403) 452-9100

British Columbia

Penticton, Dominion Radio Astrophysical Observatory, Box 248, White Lake Road, V2A 6K3, L.A. Higgs, (604) 493-2277
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Vancouver, Science World British Columbia, 1455 Quebec Street, V6A 3Z7, Gillian Lunde, (604) 443-7440
Vancouver, University of British Columbia Observatory, Dept. of Geophysics and Astronomy, 129-2219 Main Mall, V6T 1Z4, Jaymie Matthewss, (604) 822-2267
Victoria, Climenhaga Observatory, University of Victoria-Dept. of Physics, Box 3055, V8W 3P6, Russell Robb, (604) 721-7750
Victoria, Dominion Astrophysical Observatory, 5071 W. Saanich Road, RR 5, V8X 4M6, James Hesser, (604) 363-0001

Manitoba

Winnipeg, Lockhart Planetarium, University of Manitoba, 210 Dysart Road, R3T 2M8, Ian Cameron, (204) 474-9785
Winnipeg, Manitoba Planetarium, Museum of Man & Nature, 190 Rupert Ave., R3T 0E1, Ed Barker, (204) 956-2830

Nova Scotia

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Halifax, Halifax Planetarium, Nova Scotia Museum, Summer Street, B3H 3A6, (902) 429-4610

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Ottawa, National Museum of Science & Technology, 1867 St. Laurent Blvd., K1G 5A3, Michel Labrecque, (613) 991-9219
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Notre Dame Des Bois, Mont Megantic Observatory, Chemin de Lamontagne, J0B 2E0, Bernard Malenfant, (819) 888-2755

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Juneau, Marie Drake Planetarium, 10014 Crazy Horse Dr., 99801, Nancy Waterman, (907) 463-1700

Arkansas

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Cocoa, Astronaut Memorial Space Science Center, Brevard Community College, 1519 Clearlake Road, 32922, Mike Hutton, (407) 631-7889
Davie, Buehler Planetarium, 3501 SW Davie Road, 33314, David Menke, (305) 475-6681
Daytona Beach, Museum of Arts and Sciences Planetarium, 1040 Museum Blvd., 32114, Roger R. Hoefer, (904) 255-0285
Ft. Myers, Calusa Nature Center and Planetarium, 3450 Ortiz Ave., P.O. Box 60023, 33906, Doug Lozen, (813) 275-3435
Ft. Myers, Lehigh, Milky Way Recreational Telescopes, 24 Massachusetts Road, 33936-6746, Linda Jacobson, (813) 368-6106
Gainesville, University of Florida Observatory, 211 SSRB, 32611, Robert Scott Fisher, (904) 392-2052
Jacksonville, Alexander Brest Planetarium, Jacksonville Museum of Sciences and History, 1025 Museum Circle, 32207-9053, Kathleen M. Poe, (904) 396-7061 ext. 253
Kennedy Space Center, Delaware North Park Services of Spaceport, Kennedy Space Center, Mail Code DNPSS, 32899, Rich Renaud, (407) 452-2121
Melbourne, Space Coast Science Center, 1510 Highland Ave., P.O. Box 36-1816, 32936, Robert G. Tuck, Jr., (407) 259-5572
Miami, Miami Space Transit Planetarium, 3280 South Miami Ave., 33129, Bill Dishong, (305) 854-4242
North Palm Beach, Aldrin Planetarium & Gibson Observatory, 4801 Dreher Trail North, 33405, Gary Bogner, (407) 832-1988
Orlando, John Young Planetarium, 810 East Rollins Street, 32803, Paul Trembly, (407) 896-7151
Pensacola, Owens Planetarium, Science and Space Theater, Pensacola Junior College, 1000 College Blvd., 32504, Clint Hatchett, (904) 484-2516
St. Augustine, Fountain of Youth Planetarium, 155 Magnolia Ave., 32084, (904) 829-6138
St. Petersburg, Science Center of Pinellas Co. Planetarium, 7701 22nd Ave. North, 33710, Cindy Paquin, (813) 384-0027
St. Petersburg, St. Petersburg Junior College Planetarium, 5th Ave. North at 69th Street, 33710, Kenneth E. Perkins, (813) 341-4320
Tallahasee, Observatory, Dept. of Physics, Florida A&M University, 32307, Bill Tucker
Tallahasee, Pat Thomas Planetarium, Florida State University, Dept. of Physics B-159, 32306, Gerry Hart, (904) 644-6822
Titusville, U. S. Astronaut Hall of Fame, Kennedy Space Center, 32780, (407) 269-6100

Georgia

Albany, Wetherbee Planetarium, 100 Roosevelt Ave., 31701, Bob Dunagan, (912) 431-1136
Atlanta, Fernbank Science Center, 156 Heaton Park Dr. NE, 30307, David A. Dundee, (404) 378-4311
Columbus, Patterson Planetarium, 2900 Woodruff Farm Road, 31907, Carol Rutland, (404) 568-1730
Dahlonega, Coleman Planetarium, North Georgia College, 30597, Joseph H. Jones, (706) 864-1511
Decatur, Agnes Scott College, Bradley Observatory, 141 E. College Ave., 30030-3797, Dr. Alberto Sadun, (404) 371-6265
Fairmount, Sunrise Planetarium and Science Museum, Camp Sunrise, 1427 Slate Mine Road SE, 30139-2835, Jack E. Wagner, (706) 337-2776
Macon, Mark Smith Planetarium, Museum of Arts and Sciences, 4182 Forsyth Road, 31210-4806, Jim Greenhouse, (912) 477-3232
Rock Spring, Walker County Science Center, P.O. Box 10, 322 Highway 95, 30739, Wayne Robinson, (706) 764-1111
Savannah, Savannah Science Museum, 4405 Paulsen Street, 31405, Vickie Watson, (912) 355-6705
Statesboro, Georgia Southern University Planetarium, Landrum Box 8031, 30460, Dr. Marion Mobley, (912) 681-5292

Space Places

Valdosta, Valdosta State College Planetarium, Dept. of Physics, Astronomy and Geology, 31698, Martha A. Leake, (912) 333-5752

Young Harris, Rollins Planetarium, Young Harris College, 30582, James R. Westlake, Jr., 706) 379-3111

Hawaii

Hilo, Mauna Kea Observatories Support Services, 177 Makaala Street, 96720, Ronald Koehler, (808) 935-3371

Honolulu, Bishop Museum and Planetarium, 1525 Bernice Street, P.O. Box 19000-A, 96817, (808) 848-4102

Honolulu, Mauna Kea Observatories, Institute for Astronomy, 2680 Woodlawn Dr., 96822, (808) 948-8312

Kamuela, Canada-France-Hawaii Telescope, Mauna Kea, P.O. Box 1597, 96743, (808) 885-7944

Idaho

Caldwell, Whettenberger Planetarium, College of Idaho, 2112 Cleveland, 83605, Barbara Porter, (208) 459-5011

Illinois

Bloomington, Observatory, Illinois Wesleyan University, 61702, R. G. Watson, (309) 556-3060

Champaign, William M. Staerkel Planetarium, Parkland College, 2400 West Bradley Ave., 61821-1899, David Linton, (217) 351-2568

Chicago, Adler Planetarium, 1300 South Lake Shore Dr., 60605, Karol Cooper, (312) 322-0337

Chicago, Museum of Science & Industry and Crown Space Center, 57th Street and Lake Shore Dr., 60637, Steve Bishop, (312) 684-1414, ext. 2500

Evanston, Dearborn Observatory, Northwestern University, 2131 Sheridan Road, 60208-2900, Paula Napora, (708) 491-7650

Joliet, Herbert Trackman Planetarium, Joliet Junior College, 1216 Houbolt Ave., 60436, Edward Eichelberger, (815) 729-9020 ext. 2115

Kankakee, Strickler Planetarium, Olivet Nazarene University, P.O. Box 592, 60901-0592, Troy Stoneking, (815) 939-5267

Normal, Illinois State University Planetarium, Physics Dept., College Ave. and School Street, 61790-4560, Carl J. Wenning, (309) 438-8756

Peoria, Lakeview Museum of Arts and Sciences, 1125 West Lake Ave., 61614-5985, Sheldon Schafer, (309) 686-7000

River Grove, Cernan Earth & Space Center, Triton College, 2000 Fifth Ave., 60171, Bart Benjamin, (708) 456-0300 ext. 3372

Rockford, Discovery Center Museum, 711 North Main Street, 61103-6903, Sue Hudson, (815) 963-6769

Rockford, Time Museum, 7801 East State St., I-90 and Business 20, 61108, Dorothy Mastricola, (815) 398-6000, ext. 2493

Urbana, University of Illinois Observatory, 103 Astronomy Building, 1011 N. Springfield Ave., 61801, Greg Rudnick, (217) 338-3090

Indiana

Bloomington, Kirkwood Observatory, Indiana University, 47401, David Vesper, (812) 855-6911

Evansville, Koch Science Center and Planetarium, 411 SE Riverside Dr., 47713, Mitch Luman, (812) 425-2406

Evansville, Wahnseidler Observatory, P.O. Box 3474, 47733, Scott Conner, (812) 922-5681

Fort Wayne, E. C. Schouweiler Planetarium, Saint Francis College, 2701 Spring Street, 46806, Albert L. Hennig, (219) 434-3278

Greencastle, McKim Observatory, DePauw University, Dept. of Physics and Astronomy, 46135, Mary P. Kertzman, (317) 658-4654

Indianapolis, Holcomb Observatory & Planetarium, Butler University, 4600 Sunset Ave., 46208, Chris Price, (317) 940-9951

Indianapolis, Spacequest Planetarium, Children's Museum of Indianapolis, 3000 North Meridian Street, 46208, Lisa Harmon, (317) 924-5431

Marshall, Turkey Run State Park Nature Center, Route 1, Box 164, 47859-9764, Barbara Mummey, (317) 597-2635

Merrillville, Merrillville Community Planetarium, Clifford Pierce Middle School, 199 East 70th Ave., 46410, Gregg L. Williams, (219) 736-4856

Muncie, Ball State University Planetarium, Dept. of Physics & Astronomy, 47306, Planetarium Director, (317) 285-8871

North Manchester, Charles S. Morris Observatory, Manchester College, 46962, Dwight B. Berry, (219) 982-5070

Terre Haute, John C. Hook Memorial Observatory, Indiana State University, 47809, Robert C. Howe, (812) 237-2444

Vincennes, Dunseth Planetarium, Vincennes University Community College, 47591, (812) 885-4229

Iowa

Bettendorf, Donald A. Schaefer Planetarium, Bettendorf High School, 3333-18th Street, 52722, Pete Sweedy, (319) 332-7001

Cedar Falls, Hillside Observatory, University of Northern Iowa, Dept. of Earth Sciences, 50614, Thomas Hockey, (319) 273-2389

Cherokee, Sanford Museum and Planetarium, 117 East Willow Street, 51012, Terry Walker, (712) 225-3922

Decorah, Luther College Planetarium, Physics Dept., 700 College Dr., 52101, Ken Larson, (319) 387-1117

Des Moines, Drake University Municipal Observatory, Drake University, Observatory Road, 50311, L.P. Staunton, (515) 271-3141

Des Moines, Science Center of Iowa, 4500 Grand Ave., 50312, Morris H. Mason, (515) 274-6868

Dubuque, Heitkamp Memorial Planetarium, Loras College, Dept. of Physics, 52001, Jim Clark, (319) 588-7100

Waterloo, Grout Museum of History and Science, 503 South Street, 50701, Aaron Spurr, (319) 234-6357

Kansas

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Great Bend, Barton County Community College Planetarium, Bissells Point Road, 67455, Gillian Gabelmann, (316) 792-2101

Greensburg, Pallasite Meteorite, The Big Well, 315 South Sycamore, 67054, Mary L. Keller, (316) 723-2261

Hutchinson, Kansas Cosmosphere & Space Center, 1100 North Plum Street, 67501, Kim Arnold, (316) 662-2305

Salina, Kansas Wesleyan University Observatory, 100 E. Claflin, 67401, David Clark, (800) 874-1154

Topeka, Washburn University Planetarium, 17th and College, 66621, Darrell Parnell, (913) 231-1010 x1332

Wichita, Lake Afton Public Observatory, 1845 Fairmount, 67260-0032, Greg Novacek, (316) 689-3191

Wichita, Omnisphere and Science Center, 220 South Main Street, 67202, Jose Olivarez, (316) 337-9174

Kentucky

Berea, Weatherford Planetarium, Berea College, CPO 2326, 40404, Smith Powell, (606) 986-9341

Georgetown, Georgetown College Planetarium, 400 E. College Street, 40324-1696, Sharon Smith, (502) 863-8436

Golden Pond, Golden Pond Planetarium, 100 Van Morgan Dr., Land Between the Lakes, 42211, Tom Call, (502) 924-1295

Louisville, Museum of History & Science, 727 West Main Street, 40202, Shelley Georgehead, (502) 561-6103

Louisville, Rauch Memorial Planetarium, University of Louisville, Belknap Campus, 40292, Jann Hall, (502) 852-6665

Richmond, Hummel Planetarium, Eastern Kentucky University, 40475, Jack K. Fletcher, (606) 622-1547

Louisiana

Kenner, Freeport McMoran Daily Living Science Center, 409 Williams Blvd., 70062, Michael Sandras, (504) 468-7229

Lafayette, Lafayette Natural History Museum, 637 Girard Park Dr., 70503, Dave Hostetter, (318) 268-5544

Luling, St. Charles Parish Public Library & Planetarium, 105 Lakewood Dr., 70070, Gary J. Meibaum, (504) 785-8471

New Orleans East, Louisiana Nature Center, Joe W. Brown Memorial Park, P.O. Box 870610, 70187-0610, Mark Trotter, (504) 243-3385

Maine

Castine, Maine Maritime Academy, 04420, William Corbett, (207) 326-4311

Easton, Francis Malcolm Science Institute, P.O. Box 186, U.S. Route 1-A, 04740, Lawrence Berz, (207) 488-5451

Fairfield, Northern Stars Planetarium, 4 Osborne Street, 04937, John T. Meader, (207) 453-7668

Lewiston, Bates College Planetarium, Dept. of Physics & Astronomy, 44 Campus Ave., 04240, Eric Wollman, (207) 786-6490

Orono, Maynard E. Jordan Planetarium, University of Maine , 5781 Wingate Hall, 04469-5781, Alan Davenport, (207) 581-1341

Portland, Southworth Planetarium, University of So. Maine, 96 Falmouth Street, 04104-9300, Roy A. Gallant, (207) 780-4249

Maryland

Annapolis, McKeldin Memorial Planetarium, St. John's College, 60 College Ave., 21401, Roy Armstrong, (301) 263-2371

Annapolis, Planetarium, U.S. Naval Academy, Luce Hall Seanav, 21402, (301) 267-3952

Baltimore, Community College of Baltimore Planetarium, 2901 Liberty Heights Ave., 21215, Charles F. Robinson, (301) 396-7994

Baltimore, K. Brice Bryan Planetarium, College of Notre Dame, 4701 N. Charles Street, 21210, Joseph Di Rienzi, (301) 435-0100

Baltimore, Maryland Science Center, Davis Planetarium, 601 Light Street, 21230, Jim O'Leary, (410) 685-2370

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Hagerstown, Washington County Planetarium, 823 Commonwealth Ave., 21740, Rod Martin, (301) 791-4172

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Worton, Kent County High School Planetarium, 25301 Lambs Meadow Rd., 21678-0047, Dennis Herrmann, (410) 778-4540

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Amherst, Five College Radio Observatory, University of Massachusetts, 01002, (413) 545-2194
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Boston, Boston University, Dept. of Astronomy, 725 Commonwealth Ave., 02215, Frank Sienkiewicz, (617) 353-5700
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Cambridge, Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, 02138, Julie Corliss, (617) 495-7461
Cambridge, Wallace Astrophysical Observatory, MIT, Building 54-410, 02139, Heidi Hammel, (617) 253-9317
Deerfield, Peter C. Andrews Planetarium, Deerfield Academy, 01342, David Howell, (413) 772-0241 ext. 3470
Fall River, B.M.C. Durfee High Planetarium/Observatory, 314 June Street, 02720, Dennis Haworth, (508) 675-8171
Nantucket, Maria Mitchell Association, 2 Vestal Street, 02554, Eileen Friel, (508) 228-9273
Norton, Wheaton College Observatory, 02766, Timothy Barker, (508) 286-3975
Springfield, Springfield Science Museum, 236 State Street, 01103, Patrick Rowan, (413) 733-1194
Wenham, Woodside Planetarium and Observatory, 13 Friend Court, 01984, Ray Fowler, (508) 468-4815
Westford, Haystack Observatory, Route 40, 01886, Heidi Johnson, (508) 692-4764
Williamstown, Hopkins Observatory/Milham Planetarium, Williams College, Main Street, 01267, James R. Voelkel, (413) 597-2482
Worchester, New England Science Center, 222 Harrington Way, 01604, Ed Frederick, (508) 791-9211

Michigan

Alpena, Jesse Besser Museum, 491 Johnson Street, 49707, Tom Gougeon, (517) 356-2202
Ann Arbor, University of Michigan Exhibit Museum Planetarium, Room 4506, 1109 Geddes Ave. , 48109-1079, Matthew Linke, (313) 767-0478
Battle Creek, Gardner Memorial Planetarium, Kingman Museum of Natural History, West Michigan Ave. at 20th Street, 49017, David Hurd, (616) 965-5117
Bloomfield Hills, Cranbrook Institute of Science, 1221 N. Woodward Ave., 48303, Jeffery Bass, (810) 645-3230
Detroit, Children's Museum/Detroit Public Schools, 67 East Kirby, 48202, Beatrice Parsons, (313) 494-1212
Detroit, Detroit Science Center, 5020 John R Street, 48202, John Zawaskie, (313) 577-8400 x410
East Lansing, Abrams Planetarium, Michigan State University, 48824, David Batch, (517) 355-4676
Flint, Robert T. Longway Planetarium, 1310 E. Kearsley Street, 48503, Michael Gardner, (810) 760-1181
Grand Rapids, Roger B. Chaffee Planetarium, Grand Rapids Public Museum, 272 Pearl, NW, 49504, David L. DeBruyn, (616) 456-3977
Jackson, Michigan Space Center, 2111 Emmons Road, 49201, Richard Snow, (517) 787-4425
Jackson, Michigan Space Center, Jackson Community College, 2111 Emmons Road, 49201, Richard Snow, (517) 787-4425
Jackson, Peter F. Hurst Planetarium, Jackson High School, 544 Wildwood Ave., 49201, Mark Reed, (517) 783-2911
Kalamazoo, Kalamazoo Public Museum Planetarium, Kalamazoo Community College, 315 South Rose Street, 49001-4070, Eric Schreur, (616) 345-7092
Lansing, Impression Five Science Museum, 200 Museum Dr., 48933, Jan Quiring, (517) 485-8116
Lansing, Lansing Community College Planetarium, 419 N. Capitol Ave., 48910, Allan Saaf, (517) 373-7284
Grand Rapids, Lowell, James C. Veen Observatory, 3308 Kissing Rock Road SE, 49331, David L. DeBruyn, (616) 456-3985
Grand Rapids, Lowell, Kames C. Veen Observatory of the Grand Rapids Amateur Astronomical Society, 3308 Kissing Rock Road, 49331, David L. DeBruyn, (616) 897-7065
Marquette, Shiras Planetarium, Marquette Senior High School, 1203 W. Fair Ave., 49855, D. Scott Stobbelaar, (906) 225-5737
Mount Pleasant, Brooks Observatory, Physics Dept., Central Michigan University, 48859, Wayne Osborn, (517) 774-3321
Muskegon, Carr-Fles Planetarium, Muskegon Community College, 221 S. Quarterline Road, 49442, Jon Truax, (616) 777-0289
Ypsilanti, Sherzer Observatory, Eastern Michigan University, Astronomy Dept., 303 Strong Hall, 48197, Norbert Vance, (313) 487-4144

Minnesota

Duluth, Alworth Planetarium, 10 University Dr., Univ. of Minnesota-Duluth, 55812, Glenn Langhorst, (218) 726-7129
Hibbing, PauLucci Space Theater, 1502 E. 23rd Street, 55746-3357, Peter Davis, (218) 262-6718
Marshall, Southwest State University Planetarium, 1501 State Street, 56258, Roger J. Reede, (507) 537-6178
Minneapolis, Minneapolis Planetarium, 300 Nicollet Mall, 55401, Bob Bonadurer, (612) 372-6543
Moorhead, Moorhead State University Planetarium, 1104 7th Ave. S., 56563, David Weinrich, (218) 236-2904
New Ulm, Dr. Martin Luther College, 1884 College Heights, 56073, John Paulsen, (507) 354-8221
St. Cloud, SCSU Observatory and Planetarium, St. Cloud State University, 56301-4498, Mark Nook, (612) 255-2011
St. Paul, Macalester College Planetarium, 1600 Grand Ave., 55105, Sherman W. Schultz, (612) 699-6383
St. Paul, Science Museum of Minnesota/McKnight Omnitheater, 30 E. 10th Street, 55101, Mike Day, (612) 291-9403

Mississippi

Bay St. Louis, NASA John C. Stennis Space Center, Stennis Space Center, 39529, (601) 688-2370
French Camp, Rainwater Observatory and Planetarium, 1 Fine Place, 39745, James G. Hill, (601) 547-6865
Goodman, Holmes Community College Observatory, Dept. of Science and Mathematics, Holmes Community College, 39079, Michael L. Burchfield, (601) 472-2312
Hattiesburg, University of Southern Mississippi Observatory, Dept. of Physics & Astronomy, 39406, (601) 266-4934
Jackson, Dairs Planetarium, Russell Davis Planetarium, 201 East Pascagoula Street, 39201, Mary Herron, (601) 960-1550
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Jackson, Millsaps College Observatory, Dept. of Physics, 1701 North State St., 39210, (601) 974-1000
Oxford, Kennon Observatory, University of Mississippi, Dept. of Physics and Astronomy, 38677, Don Summers, (601) 232-7046

Missouri

Columbia, University of Missouri, 223 Physics Building, 65211, Physics & Astronomy Dept. Offices, (314) 882-3335
Kansas City, Kansas City Museum Planetarium, 3218 Gladstone Blvd., 64123, Michael Bakich, (816) 483-8300
Kansas City, Powell Gardens Observatory, 9912 Raytown Road, 64134, K.A. Lang
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Nebraska

Chadron, Chadron State College Planetarium, 10th & Main Street, 69337, Lois Veath, (308) 432-6219
Fremont, Lueninghoener Planetarium, Midland Lutheran College, 900 N. Clarkson, 68025, Gary A. Carlson, (402) 727-9284 x6328
Hastings, J. M. McDonald Planetarium / Hastings Museum, 1330 North Burlington Ave., 68901, Daniel Glomski, (402) 461-2399
Kearney, University of Nebraska at Kearney, 905 W. 25th Street, 68849-1160, Jose Mena-Werth, (308) 234-8277
Lincoln, Behlen Observatory, Dept. of Physics & Astronomy, University of Nebraska, 68588, Donald Taylor, (402) 472-2770
Lincoln, Hyde Memorial Observatory, South Shore Road - Holmes Park, 68506, Mary Crooks, (402) 471-7960
Lincoln, Jensen Planetarium, Nebraska Wesleyan University, 5000 Saint Paul Ave., 68504-2796, William M. Wehrbein, (402) 465-2371
Lincoln, Ralph Mueller Planetarium, University of Nebraska State-Lincoln, 213 Morrill Hall, 68588-0332, Jack Dunn, (402) 472-2641
Omaha, Mallory Kountze Planetarium, University of Nebraska at Omaha, 68th and Dodge St., 68182-0266, April L. Whitten, (402) 554-3727
Wayne, Fred G. Dale Planetarium, Wayne State College, Box 77 Wayne State College, 68787, Carl F. Rump, (402) 375-7343

Nevada

North Las Vegas, Community College of Southern Nevada Planetarium, 3200 E. Cheyenne Ave., 89030-4296, Dale A. Etheridge, (702) 651-4138
Reno, Fleischmann Planetarium, University of Nevada-Reno, 1650 N. Virginia Street, MS-272, 89557, Arthur Johnson, (702) 784-4812

New Hampshire

Concord, Christa McAuliffe Planetarium, 3 Institute Dr., 03301, John Radzilowicz, (603) 271-7831
Durham, University of New Hampshire Observatory, Dept. of Physics, Demeritt Hall U03824, Matt Loomis, (603) 862-1950
Hanover, Shattuck Observatory, Dartmouth College, Physics and Astronomy Dept., Wilder Hall, 03755, Thomas O. Kenyon, (603) 646-2034
Plymouth, Plymouth State College Planetarium, Natural Science Dept., 03264, Dennis Machnik, (603) 535-2325

New Jersey

Allendale, Northern Highlands Planetarium, Hillside Ave., 07401, Todd Sommer, (201) 934-1087
Jersey City, Liberty Science Center, 251 Phillip Street, 07304-4629, (201) 451-0006
Mountainside, Trailside Nature and Science Center, 452 New Providence Road, 07092, Bill McClain, (908) 789-3670
Newark, Dreyfuss Planetarium, Newark Museum, 49 Washington St., 07101-0540, Juliann Muller, (201) 596-6609
Randolph, County College of Morris Planetarium, 214 Center Grove Road, 07869, Albert Stoner, (201) 328-5755
Toms River, Robert J. Novins Planetarium, Ocean County College, P.O. Box 2001, 08754-2001, R. Erik Zimmerman, (908) 255-0343
Trenton, New Jersey State Museum Planetarium, 205 West State Street, 08625-0530, Richard D. Peery, (609) 292-6333

New Mexico

Alamogordo, Clyde W. Tombaugh Omnimax Theater and Planetarium, Top of NM Highway 2001, P.O. Box 533, 88310, Michael Turner, (505) 437-2840
Albuquerque, University of New Mexico Observatory, Dept. of Physics and Astronomy, 800 Yale Blvd. 87131, Stephen Gregory, (505) 277-2616
Farmington, San Juan College Planetarium, San Juan College, 4601 College Blvd., 87402, William Spargo, (505) 599-0361
Roswell, Robert H. Goddard Planetarium, 11th and North Main, 88201, Bess Amaral, (505) 624-6744
Sapello, Star Hill Inn, Box 1A, 87745, Blair Mahon, (505) 425-5605
Socorro, National Radio Astronomy Observatory-Very Large Array, P.O. Box O, 87801, Dave Finley, (505) 835-7000
Sunspot, Apache Point Observatory, P.O. Box 59, 88349, Bruce Gillespie, (505) 437-6822
Sunspot, ARC Telescope, N. M. State Univ., Dept. of Astronomy, Box 30001, Dept. 45000, Las Cruces, 88003, Kurt Anderson, (505) 646-4438
Sunspot, National Solar Observatory, Sacramento Peak, 88349, Deborah A. Haber, (505) 434-7000

New York

Alfred, Stull Observatory, Alfred University, 14802, Dr. G. David Toot, (607) 871-2208
Binghamton, Roberson-Kopernik Science, 30 Front Street, 13905, E. Jay Sarton, (607) 772-0660
Bronx, Northeast Bronx Planetarium, 750 Baychester Ave., 10475, Terry Buchalter or Charles Feldman, (718) 904-5520
Brooklyn, Edwin P. Hubble Planetarium, 1600 Ave. L, 11230, Sam Storch, (718) 258-9283, ext. 492
Buffalo, Whitworth Ferguson Planetarium, Buffalo State College, 1300 Elmwood Ave., 14222-1095, Arthur Gielow, (716) 878-4911
Centerport, Vanderbilt Planetarium, 180 Little Neck Road, 11721, Ed Quaranta, (516) 854-5555
Flushing Meadows - Corona Park, New York Hall of Science, 47-01 111th Street, 11368, Jessica DeLima, (718) 699-0005
Geneseo, SUNY-GENESEO Telescope Facility, 1 College Circle, 14454, David D. Meisel, (716) 245-5282
Herkimer, Herkimer County BOCES Planetarium, 400 Gros Blvd., 13350, Theodore Stalec, (315) 867-2000
Ithaca, Cornell University Observatory, Dept. of Astronomy, Space Sciences Bldg., 14850, Philip Nicholson, (607) 255-4935
Ithaca, Spacecraft Planetary Imaging Facility, 317 Space Sciences Building, Cornell University, 14853-6801, Rick Kline, (607) 255-3833
Middle Island, Longwood District Planetarium, 41 Yaphank Middle Island Road, 11953, Joseph E. Caprioglio, (516) 345-2741
N. Massapequa, Plainedge Planetarium, Packard Middle School, N. Idaho, 11758, Tom Carey, (516) 755-5723
New Paltz, John R. Kirk Planetarium, State University College, CSB 28, 12561, Thomas M. Crepet, (914) 257-3818
New York, American Museum-Hayden Planetarium, Central Park West at 81st Street, 10024-5192, Pamela Schwartz, (212) 769-5900
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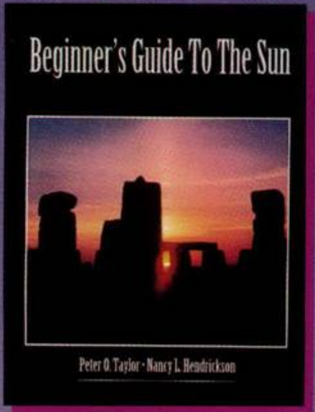
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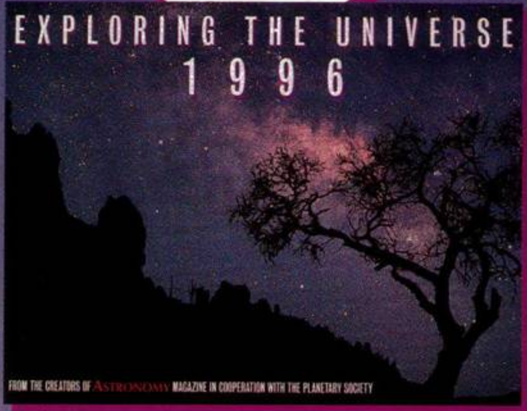
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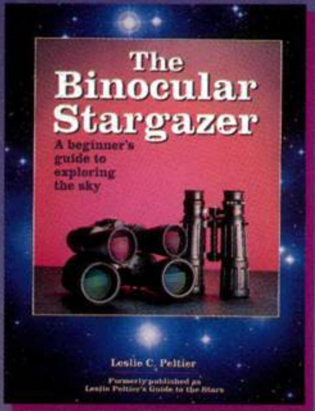
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Most armchair and backyard astronomers want to use their computers to explore the richness of the night sky and the fascinating objects it contains. A computer can save time and drudgery by making finder charts, plotting the position of a new comet, and entering notes from an observing session so observers can spend more time at the telescope. And it will also let them control a scope from the comfort of their home.

But computers do more than save labor. They also present the universe in ways unimagined so users can hike the surface of Mars, build binary star systems, watch ancient solar eclipses, visualize light passing through a telescope, tour the Local Group of galaxies, and much more.

Selecting software involves many personal choices, so this guide can't say which programs are best for you. But to help you decide, it does indicate which programs are DOS-, Windows-, or Mac-based and which require special hardware such as a CD-ROM drive or a particular display.

Astronomical software falls into several main categories: observing programs, image-processing programs, and special-purpose programs. Observing programs contain three subgroups: planetarium programs, deep-sky-observing programs, and observatory programs. (See "The Electronic Sky.")

Planetarium programs show the positions of stars and planets, display constellation figures, and plot deep-sky objects such as star clusters and galaxies. A special type of planetarium program is the sky simulator, which adds twilight glow and other features to mimic the sky. It doesn't plot constellation lines or coordinate grids as a planetarium program does, but it outdoes the planetarium program at showing how the sky really appears at night.

Deep-sky observing programs excel at showing the positions of numerous galaxies, nebulae, and star clusters. These programs also show the positions of stars, sometimes plotting fainter stars than planetarium programs. They also print finder charts for use at a telescope.

Observatory programs operate a telescope from a computer. In most cases the developers combine a planetarium program with a telescope controller. So finding an object becomes as simple as moving a cursor to it on a sky map displayed on the monitor and clicking on a mouse to move the scope.

Image-processing programs enhance images with a variety of techniques that mimic what photographers perform in their darkrooms. (See "Image Processing.")

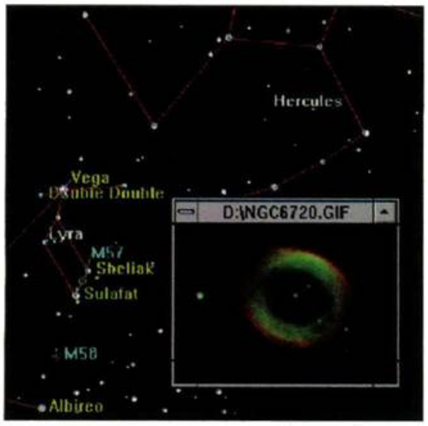
Special-purpose programs explore binary stars, view Mars from its surface, explore telescope optics, investigate the orbits of stars and planets, make a planet, keep logs of observing sessions, and much, much more. (See "Expanding Your Horizons.")

The Electronic Sky

The most popular of all these types of astronomy programs are the observing programs that permit observers and armchair astronomers to open a window to the universe. These programs indicate the planets' positions each night, locate deep-sky objects such as nebulae and galaxies, and create finder charts for use at the telescope. They can also display the distribution of star clusters throughout the Galaxy, animate the motions of planets through the sky, and show the planets as they appear from different positions within the solar system.

The software you choose depends on

***A Brief History of Time*, CD-ROM by W. H. Freeman**



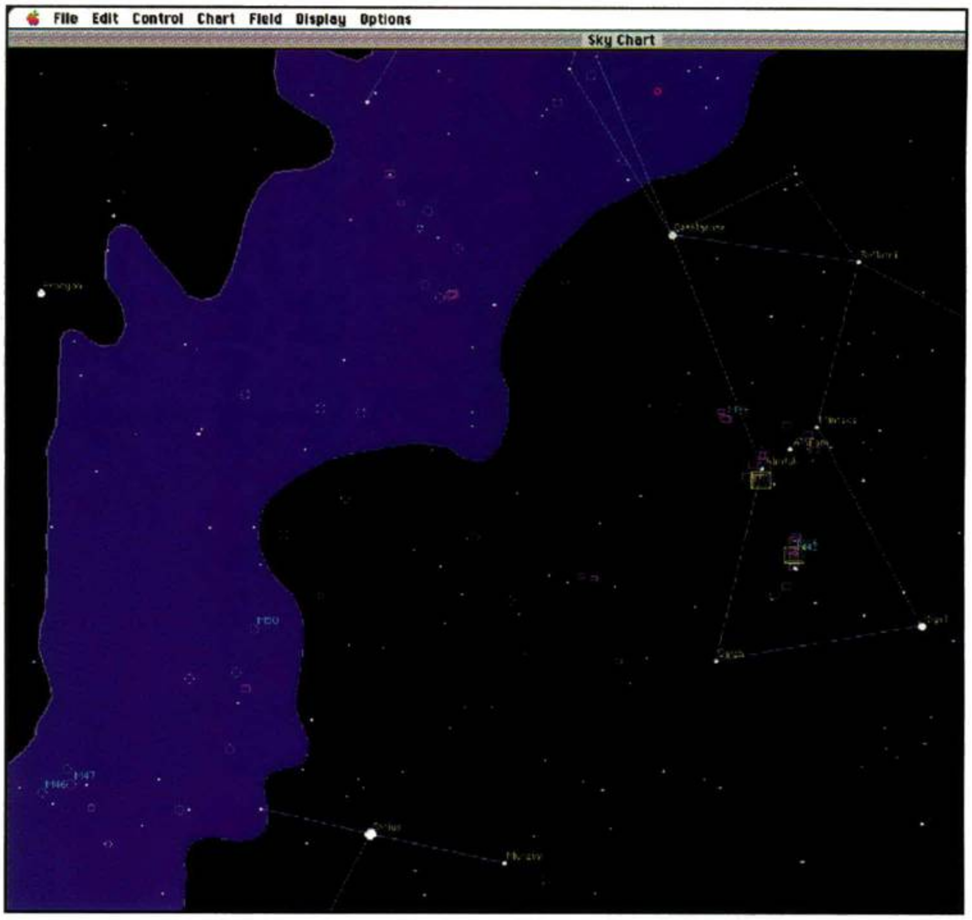
TheSky, planetarium program by Software Bisque

the observing you do or the phenomena you want to explore. One factor is the extent of their databases. Traditionally these programs have used the *Bright Star Catalog*, or a portion of this catalog, to show the positions and brightnesses of over 9,100 stars brighter than about magnitude 6.5. Others use the 250,000 stars of the *Smithsonian Astrophysical Observatory Star Catalog*, extending the brightness limit below 8th magnitude. Now many of the programs use the *Hubble Guide Star Catalog* with its over 15 million stars or provide this catalog as an option. A CD-ROM drive is needed to read this catalog.

The position and brightness of galaxies, nebulae, and star clusters form a program's deep-sky object database. Some inexpensive programs use only Charles Messier's catalog of 110 objects. Most use part or all of the *New General Catalogue* that lists almost 8,000 objects. A few deep-sky observing programs add other catalogs to include fainter nebulae, galaxies, and star clusters and allow users to customize the database to concentrate on double stars, supernova remnants, open star clusters, globular star clusters, or other types of objects.

While deep-sky programs have extensive databases, not all of them display the planets. So a planetarium-type program can still be a helpful tool for deep-sky observers, especially for finding and avoiding the bright Moon. Some planetarium programs display the positions of the four largest satellites of Jupiter and a few also feature other planetary satellites. Many include a few comets and asteroids; a few allow users to add the orbits of comets and asteroids to the database, which is useful for following new discoveries.

Some observing programs display images of the planets and some deep-sky objects or let users add personal digital images to the file. A few permit users to view QuickTime movies. These graphical features appeal greatly to organizers

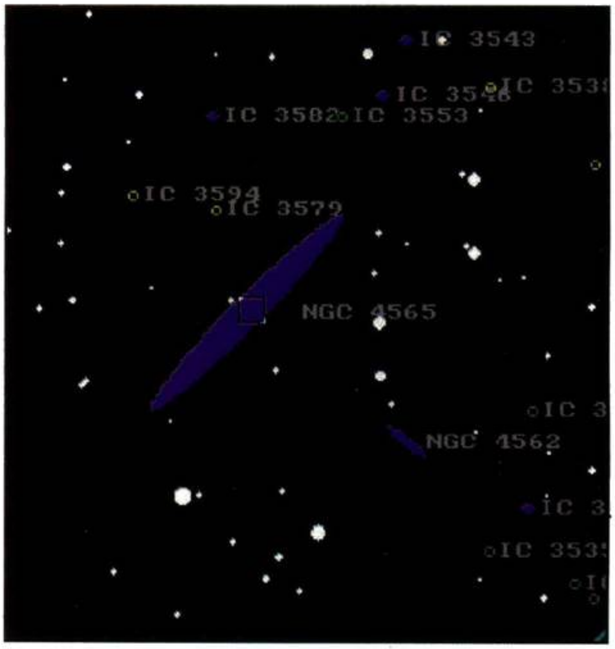


Voyager, planetarium program by Carina Software

of Astronomy Day programs, club events, school presentations, or anyone who needs a convenient means of keeping track of favorite astronomical photos.

Exploring ancient skies is one way to get a better feel for how our ancestors viewed the universe: It didn't always look the way it does today. To see the skies as they appeared more than 100 years ago or how they will be 100 years from now, choose a program that calculates precession, the slow wobble of Earth's axis over 26,000 years. Be warned that not all programs are precise enough to compute planetary positions far into the past or future, so check the program's accuracy.

Most programs can animate the motions of solar system events such as the next solar eclipse or the path of an upcoming opposition. The animation feature can also find conjunctions (groupings of the planets in the sky) and possible occultations (events that occur when the Moon passes in front of a star).



MegaStar, deep-sky program by E.L.B. Software

A few programs can store these animations as QuickTime movies for viewing outside of the program.

A useful feature to look for in a program is its ability to print finder charts. If the program can print finder charts, be

PLANETARIUM PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB
Big Blue Skies		Andromeda Soft.	S	PC	DOS		—	—	VGA	1,500	—	3,200 stars
Dance of the Planets	2.71	ARC Sci. Sim.	$125	PC (286)	DOS		2MB	640KB	VGA	9,200	1,300	yes
Dance of the Planets	Q.E.D.	ARC Sci. Sim.	$175	PC (286)	DOS		2.5MB	640KB	VGA	9,200	1,300	yes
Deep Space	5	David Chandler	$89	PC (386)	DOS		14MB	2MB	VGA		10,000	
Deep Space	5	David Chandler	$129	PC (386)	DOS	X	14MB	2MB	VGA	15 million	10,000	
Distant Suns	4.2	Virtual Reality	$99.95	Amiga			—	1MB	—	—	2,000	yes
Distant Suns	2.0	Virtual Reality	$99.95	Mac	6 or 7		3.5MB	2MB	—	10,000	2,000	
Distant Suns	2.0	Virtual Reality	$149.95	Mac	6 or 7	X	3.5MB	2MB	—	15 million	—	
Distant Suns	2.0	Virtual Reality	$69.95	PC (386)	Win 3.1		5.5MB	2MB	VGA	9,100	450	
Distant Suns	2.0	Virtual Reality	$149.95	PC (386)	Win 3.1	X	5.5MB	2MB	VGA	15 million	—	
Distant Suns-First Light		Virtual Reality	$99.95	PC (386)	Win 3.1	X	5MB	4MB	color	15 million	—	
Earth Centered Universe	2.0	Nova Astronomics	$50	PC (386)	Win 3.1		3.4MB	1MB	VGA	255,000	10,500	yes
Expert Astronomer		Expert Software	$49.95	Mac	6.0.4		1.3MB	2MB	—	9,100	110	
Expert Astronomer		Expert Software	$14.95	PC	DOS		no	512KB	CGA	9,100	110	
Expert Astronomer		Expert Software	$14.95	PC	Win 3.1		yes	2MB	VGA	9,100	110	
Expert Astronomer		Expert Software	$49.95	PC	Win 3.1	X	yes	4MB	VGA	9,100	3,000	
Genesis	3.0	Lewis-Michaels Eng.	$69.95	PC (286)	DOS		15MB	—	CGA	259,000	7,840	yes
LodeStar	2.1	Zephyr Services	$89.95	PC	DOS		—	—	CGA	9,000	110	
LodeStar Plus II		Zephyr Services	$149.95	PC	DOS		no	—	CGA	9,100	7,840	260,000 stars
LodeStar Pro	1.02	Zephyr Services	$259.95	PC (286)	DOS	optional	3MB	2 MB	VGA	9,100	110	yes
MacStronomy	2.0	Etlon Software	$60	Mac	6.0.4		yes	2MB	—	9,100	1,100	yes
NightSky		Zephyr Services	$59.95	PC	DOS		—	—	CGA	9,000	—	
NightSky		Zephyr Services	$79.95	PC	DOS		—	—	CGA	50,000	—	
PC SKY	1.1	CapellaSoft	$99	PC (286)	DOS		3.2MB	640KB	VGA	178,000	200	
PLAstro		Zephyr Services	$99.95	PC	DOS		2.5MB	—	VGA	9,100	—	
Redshift		Maris Multimedia	$59	Mac	7	X	1.5MB	4MB	color	200,000	40,000	
Redshift		Maris Multimedia	$59	PC	Win 3.1	X	1.5MB	4MB	SVGA	200,000	40,000	
Silicon Sky	6.2	Algol Software Works	$12	PC	DOS		—	—	EGA	—	—	
Sky Chart	2.3	ISIS (CompuScope)		PC	Win		1MB	4MB	VGA	250,000	10,000	yes
Sky Chart	2.3	ISIS (CompuScope)		Mac	—		1MB	4MB	VGA	250,000	10,000	yes
SkyGazer		Carina Software	$79.95	Mac	6.0.5		3MB	1MB	—	—	—	
Sky Globe	3.6	KlassM Software	$20	PC	DOS		no	640KB	CGA	29,000	110	yes
SkyLights		Zephyr Services	$89.95	PC	Win 3.1		yes	—	—	1,600	400	
StarGaze	2.1	C.E.B. Metasystems	$99.95	PC	DOS		6MB	640KB	EGA	500,000	9,000	yes
StarScape		Zephyr Services	$89.95	PC	Win 3.1		yes	—	—	9,000	—	
Superstar	4	picoScience	$149.95	PC	DOS		10MB	640KB	VGA	259,000	7,800	yes
Superstar Pro	4	picoScience	$249.95	PC	DOS		10MB	640KB	VGA	259,000	7,800	yes
The Cosmos	4.0	Mensys	$89	PC (386)	OS/2 2.0		5MB	—	VGA	9,100	10,400	yes
TheSky level II		Software Bisque	$129	PC (386)	Win 3.X	optional	5MB	4MB	VGA	47,000	8,700	yes
TheSky level III		Software Bisque	$199	PC (386)	Win 3.X	optional	18MB	4MB	VGA	259,000	21,000	yes
TheSky IV		Software Bisque	$249	PC (386)	Win 3.X	X	3MB	4MB	VGA	15 million	87,500	
Visible Universe	6	Parsec Software	—	PC	DOS		4MB	2MB	VGA	—	—	—
Voyager II	2.0	Carina Software	$159.50	Mac	6.0.7	optional	yes	1.5MB	—	259,000	12,000	yes
Voyager		Carina Software	$124.95	Amiga	—		—	1MB	—	9,100	1,200	yes

DEEP-SKY PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB
Arizona Database	8.0	Arizona Database	$89.95	PC	DOS		13.5MB	—	—	—	60,000	
Dark Sky	1.0	Arizona Database	$129.95	PC	Win		—	—	—	259,000	61,000	
Guide	4.0	Project Pluto	$69	PC	DOS	X	1MB	640KB	EGA	15 million	80,000	
HyperSky		Willmann-Bell	$49.95	PC	DOS	optional	2.4MB	500KB	CGA	46,000	5,500	yes
HyperSky		Willmann-Bell	$129.90	PC	DOS	x	2.4MB	500KB	CGA	15 million	80,000	
MegaStar	2.1	E.L.B. Software	$99	PC (386)	Win	X	3MB	4MB	VGA	15 million	84,383	
NGP	2.7	Gary Williams	F	PC	DOS		6MB	512KB	VGA	—	8,163	
Saguaro Database	6.0	Saguaro Astr. Club	$2	—	—		—	—	—	—	10,000	
Sky Tools	1.0	CapellaSoft	$119	PC (386)	Win 3.1	X	1MB	4MB	VGA	15 million	80,000	

OBSERVATORY PROGRAMS

Program Name	Version	Developer	Price	Comp	System	CD-ROM	H. Drive	Mem	Display	# Stars	# Objects	Opt DB
Epoch 2000sk		Meade Instruments	$149	PC	Win 3.1		—	—	—	250,000	20,000	
Epoch 2000sk-CD		Meade Instruments	$179	PC	Win 3.1	X	—	—	—	15 million	20,000	
Personal Observatory		CompuScope	$399	PC	DOS				VGA	—	—	
Remote Observing	1.0	Software Bisque	$299	PC	Win 3.1		yes	—	VGA	—	—	
Sky Pilot		Carina Software	$50	Mac	6.0.7		—	—		runs with Voyager II		
Stars & Scopes		So. Stars Software	$49	Mac	6.0.8		1MB	2MB	—		8,000	

An "S" in the "Price" column indicates a shareware program; if you like the program and want to keep it, you pay the developer an amount specified in the program's *documentation. An* "F" indicates a freeware program; the developer provides this program to the community free. "Display" lists the minimum requirement. The program may support higher video modes. "Opt. DB" indicates whether optional databases are available to extend either the stellar or deep-sky databases.

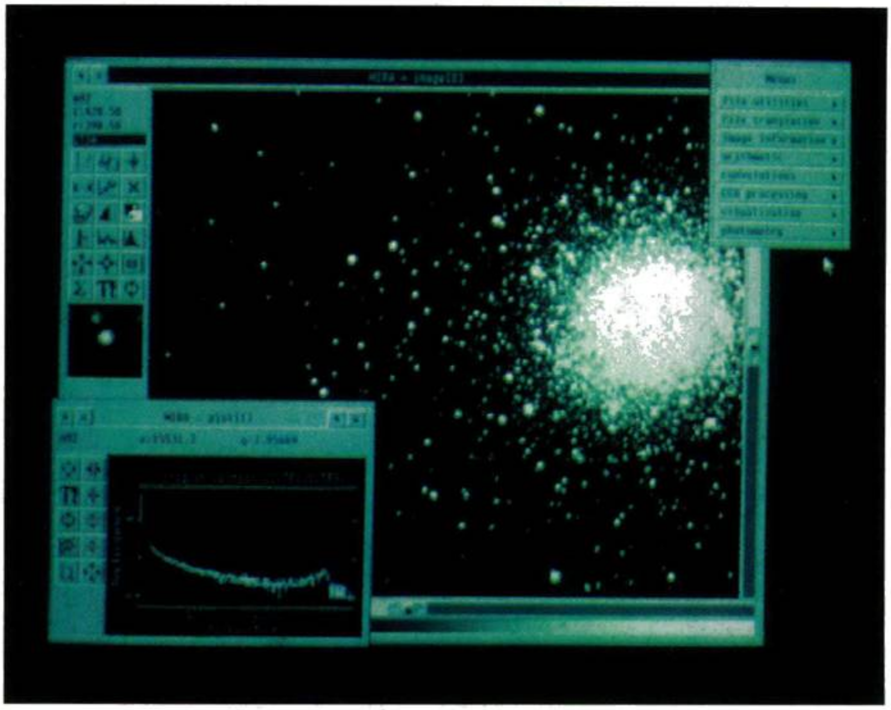
sure the chart-printing routine works with your printer. Customizing the chart is easy if the program permits a user to turn on and off the markers for different classes of deep-sky objects. Some programs allow users to attach labels to objects on the chart or to keep observing notes for each object.

Another useful feature to look for is a display of a circle on the screen showing the size of a finderscope's or eyepiece's field of view. Some programs show the actual size of an object, not just a symbol in its position, which makes selecting an eyepiece easy. One program even shows the orientation of a galaxy in the sky.

Finally, those who own a computerized scope can run it with a planetarium or observatory program. These programs are easy to use: simply select the desired object on the screen with the cursor and click the mouse button to send the telescope on its way. Many programs control Meade's LX-200 series of telescopes and some will also control a CCD camera. For another scope, check with the software developer to see if their program will work with that model.

Image Processing

Pictures of the planets, nebulae, and galaxies captivate every astronomer. To get the most from their images, many astroimagers are now turning to the digital darkroom to enhance their photos and CCD frames. But these programs aren't just for astroimagers: Anyone can use this software to stretch an image's contrast, increase its brightness, and sharpen its blurry features.



***Mira*, image-processing program by Axiom Research**

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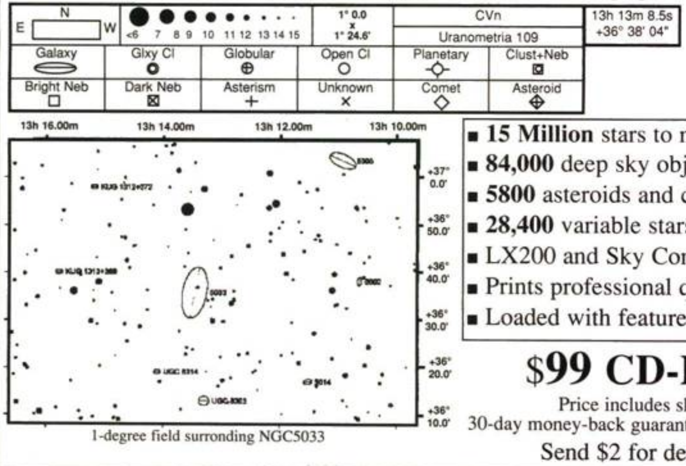

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SkyPro, image-processing program by Software Bisque

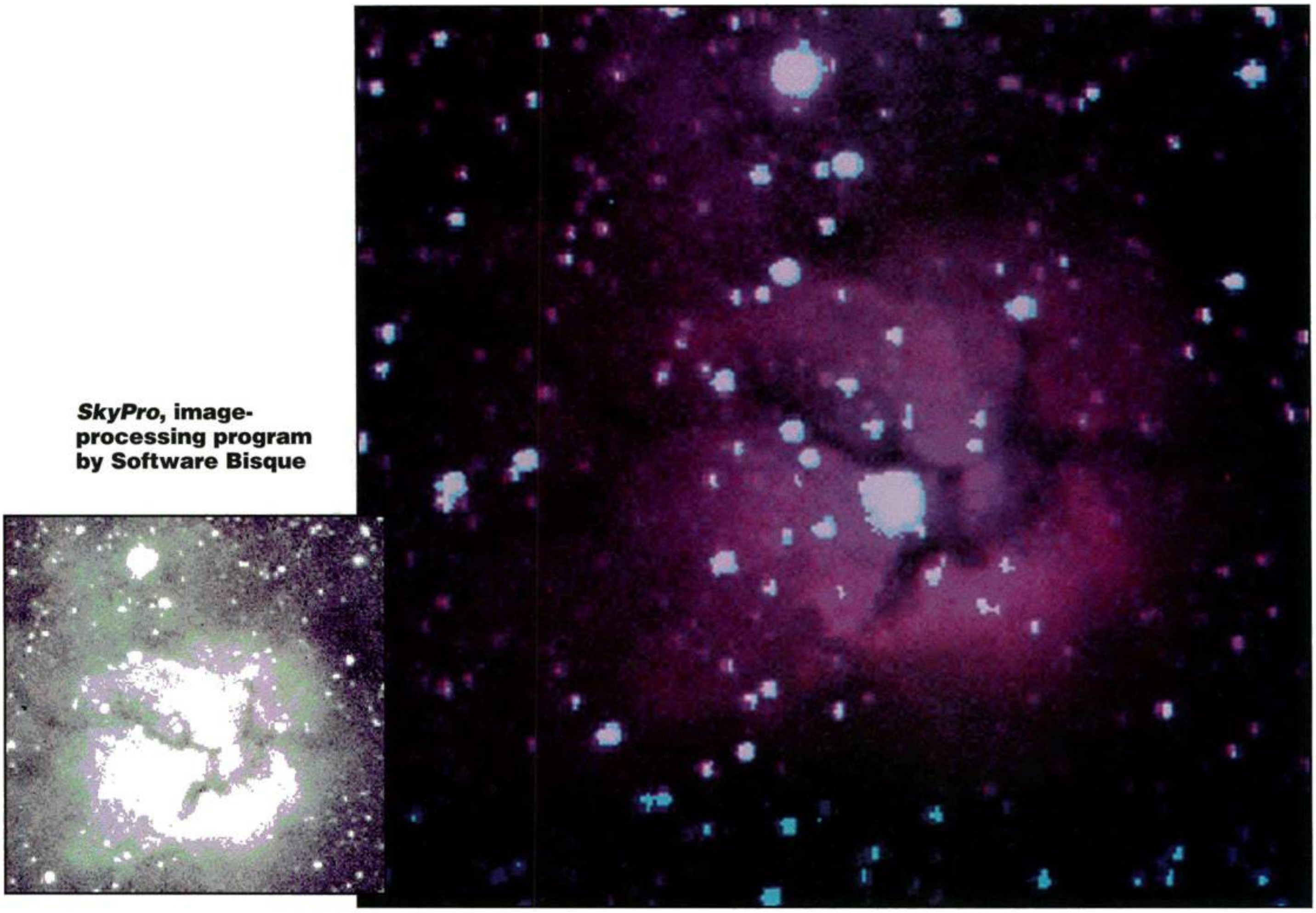

IMAGE-PROCESSING PROGRAMS

Program Name	Version	Distributor	Price	Comp	Sys.	Notes
AstroIP	1	Willmann-Bell	$29.95	PC	DOS	included with *Astronomical Image Processing*
BatchPix	60a	Richard Berry	$29.95	PC	DOS	processing of many images at one time
CB245PIX	40a	Richard Berry	$49.95	PC	DOS 6	image processing for TC245 Cookbook camera
ColorPix	50e	Richard Berry	$29.95	PC	DOS	image processing for color images
Enhance		Owl Computer Serv.	$189	PC	DOS	general image processing
EPOCH2000ip		Meade Instruments	$199	PC	Win 3.1	general image processing
Fetch	1.2	Adobe	$99	Mac	6.0.7	catalog for storing images
FOSTER CCD-ROM		Software Bisque	$69	PC	Win	introduction to image processing with demo version of SkyPro
Hidden Image 256	1.5	Sehgal Corp.	$199	PC	DOS	maximum entropy deconvolution; images up to 256 x 256 pixels
Hidden Image 512	1.5	Sehgal Corp.	$299	PC	DOS	processes images up to 512 x 512 pixels
Hidden Image 1024	1.5	Sehgal Corp.	$399	PC	DOS	processes images up to 1,024 x 1,024 pixels
MAIA	2.0	ISIS (CompuScope)	—	PC	Win	general image processing
MAIA	2.0	ISIS (CompuScope)	—	Mac	—	general image processing
Imagine-32 Pro	3.11	ISIS (CompuScope)	$250	PC	DOS	32-bit processing with special filters and Fourier transforms
Improces	3.0	John Wagner	$25	PC	DOS	GIF and PCX image editor
Kudo Image Browser	1.1	Imspace	$149	PC (386)	Win	catalog for storing images
Mathcad IP pack		MathSoft	$149	PC	Win	general image processing; requires Mathcad
MIRA A/P	1.0	Axiom Research	$350	PC (386)	DOS	powerful 32-bit image processing
Mira Professional	2.5	Axiom Research	$595	PC (386)	DOS	extended version for advanced analysis of images
MultiPIX	10a	Richard Berry	$39.95	PC	DOS	image compositing for TC211 cameras
Multi245	10d	Richard Berry	$49.95	PC	DOS	image compositing for TC245 cameras
NIH Image	1.47	NIH	F	Mac	6.0.7	general image processing
PhotoShop	3.0	Adobe Systems	$895	Mac	7	general image processing
PhotoShop	3.0	Adobe Systems	$895	PC (386)	Win	general image processing
Pixfix		Bruce Johnston Comp.	$29.95	PC	DOS	general image processing
Prism		Spectra Astro Systems	$249	PC	DOS	general image processing
QwikPIX		Willmann-Bell	$29.95	PC	DOS	included with *Choosing and Using a CCD Camera*
SBIGPIX		Richard Berry	—	PC	DOS	image processing for ST-4, ST-4X, ST-5, and ST-6 cameras
SkyPro	2.0	Software Bisque	$199	PC	Win	general image processing
SuperFix	3.1	Bruce Johnston Comp.	$69.95	PC	DOS 4.1	general image processing

negatives, prints, or slides with a special reader that converts photos into digital files. Or the local Kodak photo lab can convert the photos to digital images on a Photo CD (you need a CD-ROM drive to read these disks). Great libraries of images exist on CD-ROM (see "Megastorage") for folks who want to process images but don't want to take them.

Probably the first criterion for selecting an image-processing program is price, ranging from about $30 to $800. Options narrow quickly depending on the system because many program developers use DOS to reduce system requirements on memory.

A second feature to consider is image display. Some developers support only specific display cards because of program requirements. Others will support almost any VGA or Super VGA card.

Another factor to consider is format. Not all programs support all image file formats such as FITS or various CCD camera formats. And not all programs support color images or the combination of three separate images taken through colored filters into one tricolor image.

Inexpensive programs perform basic tasks of image processing, such as calibrating the image using flat field and bias frames and plotting histograms to show the brightness range of an image. Image calibration is an important step because it removes differences in sensitivity between pixels (picture elements in the CCD detector). This step is akin to developing film. Enhancement steps like brightness stretching and sharpening are similar to printing in the darkroom.

Inexpensive programs provide many of the basic enhancement functions and filters. Filters are mathematical tools that act in predetermined ways on adjacent pixels. An example is the high-pass filter that suppresses large-scale brightness variations in an image but maintains the small-scale (high frequency) details.

More expensive programs add additional features such as the ability to process more than one image simultaneously and include more powerful math functions, such as Fourier transforms or maximum entropy deconvolution. These functions remove the effects of bad seeing or poor guiding from the image. Several programs also work with 32-bit data, which unleashes the full power of an 80486- or Pentium-based computer. Some programs can also run a CCD camera, eliminating the need for multiple programs to obtain and process images.

Megastorage

Planetarium and deep-sky programs require large databases in order to plot large numbers of stars, galaxies, and nebulae. In the past, these programs used dozens of high-density diskettes to hold a stellar database such as the

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Starlite	Astronomical Research Network	$49.95	ARN	1,000 images of planets, galaxies, and more
Voyage to the Planets — 1	Astronomical Research Network	$149.95	ARN	Jupiter, Saturn, Uranus
Voyage to the Planets — 2	Astronomical Research Network	$149.95	ARN	Neptune and moons
Voyage to the Planets — 3	Astronomical Research Network	$149.95	ARN	Mars as seen by Viking orbiters and landers
Voyage to the Planets — 4	Astronomical Research Network	$149.95	ARN	Venus
Voyage to the Planets — 5	Astronomical Research Network	$149.95	ARN	1,000 images of Mercury from Mariner 10
Voyage to the Planets — 7	Astronomical Research Network	$149.95	ARN	Hundreds of Moon images from the Apollo missions
Voyage to the Stars — 1	Astronomical Research Network	$149.95	ARN	galaxies
Voyage to the Stars — 2	Astronomical Research Network	$149.95	ARN	David Malin collection of deep-sky objects
Voyage to the Stars — 3	Astronomical Research Network	$149.95	ARN	IRAS infrared sky images
Voyage to the Stars — 4	Astronomical Research Network	$149.95	ARN	Rudy Schild collection of deep-sky objects
Voyage to the Stars — 8	Astronomical Research Network	$149.95	ARN	Halton Arp collection of peculiar galaxies
Space Science Sampler vols 1&2	Randal Davis, Univ. of Colorado	—	PDS	800 Uranus images from Voyager on 2 disks
Comet Collision with Jupiter	Geppetto and Son	$19.95	—	300 images of Shoemaker-Levy 9 impact on Jupiter
Amazing Universe	Hopkins Technology	$79.95	—	101 images of planets and deep-sky objects
The Mars and Venus CD	Nick Marella	$29.95	BMP	600 Viking and Magellan images
Voyager Moons	Nick Marella	$29.95	BMP	600 Voyager images of outer planets and their moons
Comet Halley, Int'l. Halley Watch	National Space Science Data Center	$144	FITS, PDS, and text	Halley Watch data on 24 disks
Cosmic Background Explorer	National Space Science Data Center	$43		data from DMR experiment on 1 disk
Cosmic Background Explorer	National Space Science Data Center	$12		data from DIRBE experiment on 2 disks
Einstein Observatory	National Space Science Data Center	$12	FITS	High resolution images on 2 disks
Einstein Observatory	National Space Science Data Center	$18	FITS	Images from proportional counter on 3 disks
Galileo Cruise Imaging	National Space Science Data Center	$84	PDS and VICAR	Images from Galileo on 14 disks
IRAS Sky Survey Atlas (ISSA)	National Space Science Data Center	$66	FITS	12.5° x 12.5° images on 11 disks
Pre-Magellan Venus data	National Space Science Data Center	$6	PDS	Radar and gravity data for inner planets on 1 disk
Magellan Venus data	National Space Science Data Center	$270		Radar mosaic images (FMAP) on 45 disks
Magellan Venus data	National Space Science Data Center	$756		Radar mosaic images (F-MIDR) on 126 disks
Mars Digital Image Map	National Space Science Data Center	$84	MDIM and GIF	Images of Mars on 14 disks
Mission to the Moon	National Space Science Data Center	$528	PDS	Images of Moon by Clementine on 88 disks
ROSAT: The Images	National Space Science Data Center	$36		X-ray images from the Roentgen Satellite on 6 disks
Viking Orbiter Images of Mars	National Space Science Data Center	$289	PDS	Images on 46 disks
Voyager Spacecraft to Uranus	National Space Science Data Center	$18	PDS	6,538 images on 3 disks
Voyager Spacecraft to Saturn	National Space Science Data Center	$12	PDS	4,000 images on 2 disks
Voyager Spacecraft to Jupiter	National Space Science Data Center	$90	PDS	6,000 images on 15 disks
Voyager Spacecraft to Neptune	National Space Science Data Center	$24	PDS	10,000 images on 4 disks
Welcome to the Planets	National Space Science Data Center	$6	GIF	190 images of planets, moons, comets, and spacecraft
Comet Smash	Network Cybernetics	$39	FITS, GIF, TIFF	700 images of Shoemaker-Levy 9 impact on Jupiter
Joint Education Initiative - Earth Science	Robert Ridky, Univ. of Maryland	—	PDS	Halley Watch, Voyager, and other data on 3 disks
Space	Seattle Support Group	—	—	200 images of planets and space
Space and Astronomy	Walnut Creek CDROM	$39.95	—	1,000 images of Earth, the planets, and space shuttles
Shuttle Encyclopedia	Walnut Creek CDROM	$39.95	GIF	3,000 images taken of and from space shuttles
Stars and Beyond: Images of NASA	WeMake CDs	$30	BMP, GIF, PCX	375 images of the planets
Visions of Saturn	WeMake CDs	$30	GIF	Voyager images of the ringed planet
Movies				
Apollo 8: Go for Trans-Lunar Insertion	WeMake CDs	$30	Win	First manned mission to orbit the Moon
Four Days of Gemini 4	WeMake CDs	$30	Win	First U.S. walk in space
Mars: The Search Begins	WeMake CDs	$30	Win	Viking missions, first to land on Mars
New View of Space	WeMake CDs	$30	Win	Various missions shown from launch pad into space
Catalogs				
Hubble Guide Star Catalog	Astronomical Society of the Pacific	$69.95	—	Positions and magnitudes of over 15 million stars
Principal Galaxy Catalogue	Observatorie de Lyon	$90	text	Information about 73,000 galaxies
Selected Astronomical Catalogs I	National Space Science Data Center	$25	FITS and text	120 catalogs on 2 disks
Databases				
Flares in Hydrogen Alpha	National Geophysical Data Center	$114	text	Solar flare records dating back as far as 1938
Regions of Solar Activity	National Geophysical Data Center	$114	text	Calcium plage and sunspot group data — 1958 to 1991
Solar Radio Bursts	National Geophysical Data Center	$114	text	Solar radio emissions
Solar Variability Affecting Earth	National Geophysical Data Center	$114	text	Flares, spot numbers, and solar irradiance on 1 disk
Interactive Disks				
A Brief History of Time	W.H. Freeman	$59.95	Mac/PC	Multimedia version of Stephen Hawking's book
Astronomica	Hyper-Quest	$69.95	Mac/PC	Solve a mystery at an observatory
Explore the Planets	Tasa Graphic Arts	$85	Mac/PC	Comparative tour of geologic processes on the planets
Mars Book	Human Code	$17.95	Mac	Walk through a Martian habitat designed by NASA
Space Rocks	Astronomical Research Network	$149.95	BMP	Images and information about meteorites
View from Earth	Warner New Media	$79.98	PC	Describes Earth, Sun, and Moon with text and images
Voyage through the Solar System	Palo/Haklar	$49.95	Mac/PC	Describes all the planets using text, movies, and images
Voyage to the Outer Planets	NRSPACE Software	$49.95	Win	Tours Jupiter, Saturn, Uranus, Neptune, and their moons

NOTE: Prices of disks offered by the National Space Science Data Center do not include the $30 order processing fee assessed for each order, regardless of how many disks are ordered.

***Space*, CD-ROM by Seattle Support Group**

Hubble Guide Star Catalog. Users performed the floppy shuffle to load the database ("Now Insert Diskette #43"), and then found that even large hard disks were overwhelmed with it.

CD-ROMs (compact disk, read only memory) provide a more convenient storage medium. A single disk can hold dozens of large databases and hundreds of images, up to 700 MB of data, within their 12-centimeter diameter. Because writing to the disk isn't possible, users can't accidentally erase or corrupt the database ("How did Sirius wind up in Ursa Major?").

In the last year, CD-ROM drives have increased in speed so they're now up to four times faster than their predecessors. At the same time, prices for the drives have continued to fall, making the drives standard features for home computers. Most armchair astronomers didn't bother with CD-ROM drives when they first appeared because few astronomical disks existed. Now many software developers provide their program or an optional database on CD-ROM.

In addition to their vast storage capability, CD-ROMs are cheap. The *Hubble Guide Star Catalog* with its 19 million objects would cost hundreds of dollars if purchased as a series of books. It's available on CD-ROM for just $69.95. Obtaining prints of all the planetary images now available on CD-ROM would prove costly and difficult. And manipulating those printed images would be nearly impossible compared to computer processing of digital images. Just be sure your image-processing program can read the CD-ROM's data format (FITS, GIF, and PDS are the most common ones).

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impact of CD-ROMs from databases and image storage to movies, interactive books, and multimedia presentations. Many of the present QuickTime movies are crude by home video standards, but as computer-video technology improves, we'll soon see great movies on CD-ROMs. The electronic books provide nifty animations coupled with audio versions of the printed book.

The exciting part about CD-ROMs is that the disks listed on page 78 are just the beginning. Every month, astronomers and software vendors are producing new disks. Users will soon wonder how they got along without them.

Expanding Your Horizons

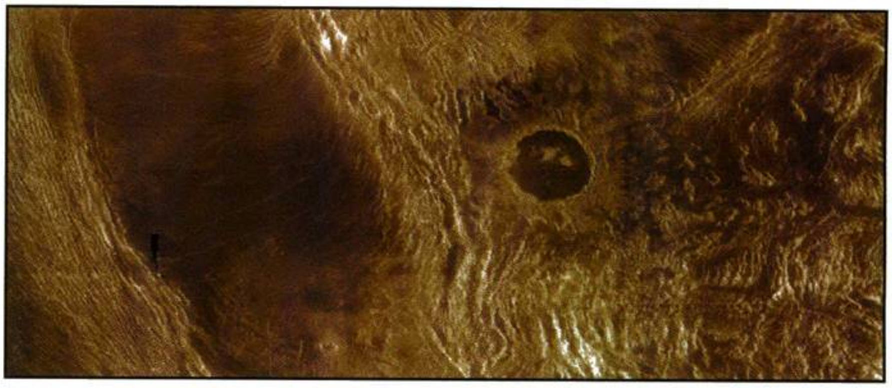
Astronomical computing has great depth beyond planetarium and image-processing programs. Special-purpose programs show how galaxies collide, why eclipses occur, when an asteroid will pass in front of a star, and what the universe looks like from another star.

Eclipse programs plot the path of an eclipse across Earth's face and predict the time of a lunar or solar eclipse more accurately than some planetarium programs. The programs indicate whether the eclipse will be partial, total, or annular (for solar eclipses) and the precise percentage of coverage as seen from any given location. Weather programs can help observers determine whether the skies may be clear on eclipse day.

Binary star programs show the motions of two stars and determine how the brightness of the star system changes as the stars pass in front of each other. Other programs demonstrate how stars emit light and change with age.

OTHER ASTRONOMY SOFTWARE

Program Name	Developer	Price	Comp	System	H. Drive	Mem	Display	Description
Admir	Willmann-Bell	$19.95	PC	DOS	no	—	—	Analyzes Foucault mirror tests
A-OK! Wings of Mercury	Innovative Technologies	$49.95	Mac	7	8MB	5.5MB	color	Simulates a mission in a Mercury space capsule
Aperture	Willmann-Bell	$24.95	PC	DOS	no	—	EGA	Displays star images produced by scopes
Asteroid Pro	Pickering Anomalies	$159.95	PC (386)	DOS	45MB	640KB	VGA	Predicts occultations of stars by asteroids
Asteroid Pro	Pickering Anomalies	$189.95	PC (386)	Win	45MB	640KB	VGA	Predicts occultations of stars by asteroids
Asteroid Pro	Pickering Anomalies	$199.95	PC (386)	DOS	45MB	640KB	VGA	Uses CD-ROM to add 6 million stars
Astro	Science.wks	$45	PC	DOS	no	384KB	—	Find positions using Lotus 1-2-3 spreadsheets
Astro-C	Science.wks	$60	PC	DOS	no	384KB	—	Calculates orbits and positions using Lotus 1-2-3
AstroCalc	Zephyr Services	$30-$200	PC	DOS	no	—	CGA-EGA	Gives planetary positions, rise and set times
AstroCalc	Zephyr Services	$129.95	PC	Win	2MB	2MB	VGA	Gives planetary positions, rise and set times
AstroFonts	Zephyr Services	$29.95	PC	Win	200KB	—	VGA	Provides TrueType font for astronomical symbols
Astronomical Formulas	MathSoft Inc.	$99	PC	Win	—	—	—	Computes magnitudes and distances
Astronomy Lab	Personal MicroCosms	$17.50	PC (386)	Win 3.1	1MB	1MB	VGA	Predicts astronomical phenomena
Astronomy Workbench	Io Solutions	$125	PC	DOS	—	—	EGA	Displays the night sky and simulates orbits
AstroPhoto	Zephyr Services	$29.95	PC	DOS	no	—	—	Calculates exposure times
Astrophys	Science.wks	$95	PC	DOS	no	384KB	—	Find brightness and distance using Lotus 1-2-3
Astrophysics with a PC	Willmann-Bell	$19.95	PC	DOS	no	—	CGA	Explores stars, clusters, and the universe
AstroPix	F.C. Meichsner	$40	PC	DOS	no	—	—	Computes exposure times for astrophotos
AstroPlanck	Zephyr Services	$29.95	PC	DOS	no	—	VGA	Demonstrates how stars radiate energy
AstroPoint IV	Dale Ferguson	$29.95	PC	DOS	no	—	CGA	Calculates positions of objects in the sky
AstroSeeker	Zephyr Services	$49.95	PC	DOS	—	—	—	Searches for astronomical events
AstroSheet	C.E.B. Metasystems	$299.95	PC	Win	—	—	—	Uses Microsoft's Excel for calculations
AstroVizier	Zephyr Services	$39.95	PC	DOS	no	640KB	CGA	Predicts planetary phenomena
Astro-3D	Zephyr Services	$30-$40	PC	DOS	no	—	CGA-EGA	Travels through the Sun's neighborhood
Beam 2	Stellar Software	$89	PC	DOS	no	—	—	Traces light through optical systems
Beam 2	Stellar Software	$89	Mac	—	—	—	—	Traces light through optical systems
Binary Maker	Contact Software	$59.95	PC	DOS	no	640KB	VGA	Simulates binary star orbits and brightnesses
Binary Star	Gemini Software	$37.50	Mac	7		2MB	color	Simulates binary star orbits and brightnesses
Canon of Eclipses	Willmann-Bell	$29.95	PC	DOS	no	640KB	CGA	Displays lunar eclipses, 1500 b.c.-a.d. 3000
CAAS Sky Guide	Gary Williams	F	PC (386)	DOS	4MB	1MB	VGA	Quizzes user on constellations and bright stars
Ceres	Zephyr Services	$159.95	PC	DOS	7MB	—	EGA	Plots paths for over 5,000 asteroids
CircumSpace	KlassM Software	S	PC	DOS	no	640KB	EGA	Travels through the Sun's neighborhood
Classify Stellar Spectra	Project CLEA	F	PC	Win	—	—	—	Demonstrates how to classify stellar spectra
COLPACK	Willmann-Bell	$29.95	PC	DOS	no	256KB	CGA	Locates celestial objects
Dark Sky Calendar	Steve Voss	$24.50	PC	DOS	120KB	192KB	—	Prints monthly calendar with Moon phases
DB-Lune	Destination Univers	$75	PC (386)	DOS	12MB	640KB	EGA	Diplays features on the Moon
Discover Space	Brøderbund	$39.95	PC (386)	DOS	7MB	640KB	VGA	Tours the solar system
Eclipse Complete	Zephyr Services	$149.95	PC	DOS	—	—	CGA	Predicts eclipses and displays path
EclipseMaster	Zephyr Services	$30-$50	PC	DOS	no	—	—	Computes solar and lunar eclipses precisely
Electronic PictureBooks	Astr. Soc. Pacific	$10-$40	Mac	7.X	yes	2.5MB	—	Contains images of planets and other objects
Floppy Almanac 19XX	Willmann-Bell	$20	PC	DOS			CGA	Provides Astronomical Almanac data
GalaxCrash	Zephyr Services	$30-$50	PC	DOS	no	—	CGA-EGA	Simulates collision of two galaxies
Galileo's Four	Zephyr Services	$29.95	PC	DOS	no	—	CGA	Shows positions of Jupiter's largest moons
Gauss and Laplace	Andromeda Software	S	PC	DOS	no	—	—	Computes orbit from three observations
Gravitator	Zephyr Services	$40-$150	PC	DOS	no	—	CGA-EGA	Computes orbits of stars and planets
Howington Orrery	Zephyr Services	$39.95	PC	DOS	no	—	CGA	Displays orbits in our solar system
Hubble Redshift	Project CLEA	F	Mac		—	—	B&W	Illustrates how to measure a galaxy's distance
Hubble Redshift	Project CLEA	F	PC	Win	—	—	—	Illustrates how to measure a galaxy's distance
ICE	Willmann-Bell	$35	PC	DOS	—	384KB	CGA	Calculates phenomena from 1800 to 2049
Interactive Ray Trace	Parsec Technology	$198	PC (386)	Win	—	1MB		Traces light through optical systems
JMoons	Andromeda Software	S	PC	DOS	no	—	EGA	Shows positions of Jupiter's largest moons
Jovian Traveler	Zephyr Services	$39.95	PC	DOS	no	—	EGA	Simulates spacecraft mission to Jupiter
Jupiter's Moon	Project CLEA	F	Mac				B&W	Uses Kepler's laws to find Jupiter's mass
Jupiter's Moon	Project CLEA	F	PC	Win			—	Uses Kepler's laws to find Jupiter's mass
Learn About Orbits	Andromeda Software	S	PC	DOS	no	—	EGA	Teaches concepts of orbital motion
Lumiview	Waldee-Wood	$23.95	PC	DOS	no	512KB	CGA	Depicts objects as seen through filters
MarsEGA	Andromeda Software	S	PC	DOS	no	—	EGA	*Locates moons of Mars*



***Venus Explorer*, program by Virtual Reality**

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Learn how a telescope works with an optical ray-tracing program. These programs reveal how individual beams of light reflect or refract through a scope's

Mars Explorer	Virtual Reality	$69.95	PC (386)	DOS	no	4MB	VGA	Maps Mars' surface; need CD-ROM drive
Messier Observer's Guide	Larry Kalinowski	S	PC (286)	DOS	3.3MB	384KB	VGA	Shows where to find Messier deep-sky objects
MICA	NTIS	$55	Mac	6.0.2	2MB	1MB	—	Computes precise planetary positions
MICA	NTIS	$55	PC	DOS	2MB	512KB	—	Computes precise planetary positions
Moon Times	Zephyr Services	$30-$40	PC	DOS	—	—	CGA-VGA	Prints Moon rise and set times and phases
MoonTracker	Zephyr Services	$30-$40	PC	DOS	no	—	CGA-EGA	Displays lunar eclipses and visibility
New Frontiers	Ocean State Publishing	$24.95	PC	Win	1MB	—	VGA	Livens up Windows screen savers
Northern Constellations	Intellimation	$39	Mac	6.0.5	—	1MB	—	Displays constellation and retells mythology
Optics Lab	Sci. Lab Software	$299	PC (486)	Win. 3.1	2MB	4MB	VGA	Traces light through optical systems
Optics Lab - Pro	Sci. Lab Software	$899	PC (486)	Win. 3.1	2MB	4MB	VGA	Traces light through optical systems
Orbits	SoftKey	$59.95	PC	DOS	no	512KB	EGA	Provides information about the solar system
Orbits	Phy. Acad. Software	$59.95	PC	DOS	no	384KB	CGA	Simulates orbits of stars and planets
Our CosmoHood	Bondono Software	$25	PC	DOS	600KB	—	EGA	Shows our Local Group of galaxies
PC GOES/WEFAX	Soft. Systems Cons.	$250	PC (286)	DOS	yes	640KB	CGA	Captures weather satellite images
PC HF Facsimile Plus	Soft. Systems Cons.	$129.95	PC (286)	DOS	yes	640KB	CGA	Captures weather images from shortwave radio
PC-Track	Andromeda Software	S	PC	DOS	no	—	EGA	Tracks Earth satellites
PEEP	C.E.B. Metasystems	$39.95	PC	DOS	yes	640KB	EGA	Finds eclipses, conjunctions, occultations
Personal Observing Log	Ohio Star Software	$20	PC (386)	Win	2MB	2MB	VGA	Records your observing notes
Photoelectric Photometry	Project CLEA	F	Mac		—	—	B&W	Shows how to measure a star's brightness
Photoelectric Photometry	Project CLEA	F	PC	Win	—	—	—	Shows how to measure a star's brightness
Planets III	Aladdin Software	$39.95	PC	Win	3MB	2MB	—	Displays pictures of and describes the planets
Planet Tracker	David Chandler	$50	PC	DOS	no	512KB	EGA	Investigates the laws of planetary motion
Plate	Zephyr Services	$49.95	PC	DOS	no	—	—	Determines position of object in photo
Ray	Phy. Acad. Software	$69.95	Mac	—	—	—	—	Traces light through optical systems
Redscope	Waldee-Wood	$19.95	PC	DOS	no	512KB	CGA	Calculates scope and eyepiece performance
Satellite Pro	Zephyr Services	$149.95	PC	DOS	yes	—	EGA	Calculates highly accurate satellite orbits
Satellite Tracker	Intellimation	$39	Mac	6.0.5	400KB	1MB	—	Tracks Earth satellites
Sharescope	Waldee-Wood	$11.95	PC	DOS	no	384KB	CGA	Calculates visual performance of scope
Silicon Universe	Algol Software Works	$12	PC	DOS	no	—	—	Shows deep-sky objects outside our Galaxy
SimEarth	Maxis	$69.95	Mac	—	—	1MB	—	Creates a planet that then evolves
SimEarth	Maxis	$69.95	PC	DOS	—	640KB	EGA	Creates a planet that then evolves
SkyClock	Bodhi Software	$79.99	PC	DOS	no	512KB	—	Provides rise and set times for planets
Solar	Andromeda Software	S	PC	DOS	no	—	CGA	Displays solar eclipses from 1951 to 2032
SolarSpace	Zephyr Services	$39.95	PC	DOS	no	—	EGA	Shows Sun's neighborhood in 3D
SolarSys	Zephyr Services	$29.95	PC	DOS	no	—	VGA	Surveys the contents of the solar system
Space Adventure	Knowledge Adventure	$59.95	PC	DOS	8MB	—	VGA	Provides a tour of the universe
Space Simulator	Microsoft	$64.95	PC (386)	DOS	15MB	2MB	VGA	Flies a spacecraft through space
Spacetime	Phy. Acad. Software	$59.95	Mac	—	—	—	—	Explores the laws of special relativity
Spacetime	Phy. Acad. Software	$59.95	PC	DOS	no	—	—	Explores the laws of special relativity
StarBase	Altair Engineering	$199	PC	Win	—	—	—	Stores your observations, images, and text
StarCrossed	Zephyr Services	$29.95	PC	DOS	no	—	VGA	Introduces variable stars
Star Probe	Artemis Software	$55	Mac	7	—	4MB	color	Studies lives and properties of stars
STS-Orbit	Andromeda Software	S	PC	DOS	no	—	CGA	Displays shuttle orbital paths
Sun Clock	Palo Alto Software	$39.95	Mac	6.0.2	—	1MB	—	Displays areas of day and night on Earth
Sun Clock	Palo Alto Software	$39.95	PC	Win	—	—	—	Displays areas of day and night on Earth
SunTracker	Zephyr Services	$30-$130	PC	DOS	—	—	CGA-EGA	Displays solar eclipses and paths
TideMaster	Zephyr Services	$39.95	PC	DOS	no	—	—	Calculates times of high and low tides
TimeChecker	Zephyr Services	$39.95	PC	DOS	no	—	—	Gets correct time from U.S. Naval Obs.
Total Eclipse	Zephyr Services	$129.95	PC	DOS	yes	—	EGA	Displays solar and lunar eclipses
TrakSat	WinTrak	$25	PC	DOS	1.2MB	1MB	CGA	Follows Earth satellites in their orbits
TS-24	Crystal Lake Observ.	$75	PC	Win	—	—	—	Simulates a telescope and displays images
VarBase	Zephyr Services	$29.95	PC	DOS	no	—	CGA	Records and displays variable star data
Venus Explorer	Virtual Reality	$69.95	Mac	—	—	—	color	Maps Venus' surface; need a CD-ROM drive
Venus Explorer	Virtual Reality	$69.95	PC	DOS	—	4MB	VGA	Maps Venus' surface; need a CD-ROM drive
Vista Pro	Virtual Reality	$129.95	Mac	7	4MB	4MB	color	Creates Martian landscapes from Viking data
Vista Pro	Virtual Reality	$129.95	PC	Win and DOS	4MB	4MB	VGA	Creates Martian landscapes from Viking data
Where in Space	Brøderbund	$79.95	PC (386)	DOS	8MB	640KB	VGA	Presents a game set in the solar system
WinTrak	WinTrak	$49.95	PC (386)	Win	4MB	4MB	VGA	Tracks Earth satellites

An "F" in the "Price" column indicates that the program is freeware. An "S" indicates it is shareware; if you like the program and wish to keep it, you must register your copy with the developer and pay the fee listed with the program documents. "Display" lists the minimum display required. The program may support higher video modes.

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http://adswww.harvard.edu/ads_services.html	Astrophysical Data System; catalogs
http://airsci-www.arc.nasa.gov/	Kuiper Airborne Obs. information
http://argo.tuc.noao.edu/	National Solar Observatory
http://blackhole.aas.org/AAS-homepage.html	American Astronomical Society
http://bradley.bradley.edu/~dware/al.html	Astronomical League
http://cass.jsc.nasa.gov/lpi.html	Lunar and Planetary Institute
http://cast0.ast.cam.ac.uk/RGO/RGO.html	Royal Greenwich Observatory
http://cdwings.jpl.nasa.gov/pds/	NASA Planetary Imaging
http://ctios2.ctio.noao.edu/ctio.html	Cerro Tololo Inter-American Observatory
http://ddo.astro.utoronto.ca	David Dunlap Observatory
http://euterpe.arcetri.astro.it	Large Binocular Telescope
http://fits.cv.nrao.edu/www/astronomy.html	Astro Web
http://http.hq.eso.org/eso-homepage.html	ESO headquarters
http://hypatia.gfsc.nasa.gov/NASA_homepage.html	NASA Information Sources
http://ic-www.arc.nasa.gov/ic/projects/bayes-group/Atlas/Mars	Mars atlas
http://info.aoc.nrao.edu/	National Radio Astronomy Observatory
http://info.cern.ch	Mother of all WWW home pages
http://info.ftp.berkeley.edu/Vol1/Contents.html	Interactive Phys
http://irtf.ifa.hawaii.edu/online	NASA Infrared Telescope Facility
http://isis.spa.umn.edu/homepage.aps.html	Palomar Observatory Sky Survey online
http://marvel.stsci.edu/net-resources.html	Astro Web
http://meteor.anu.edu.au/~pjq/macho.html	MACHO dark-matter search status
http://newproducts.jpl.nasa.gov/sl9/sl9.html	Comet Shoemaker-Levy 9 impact images
http://nssdca.gfsc.nasa.gov/nmd.html	NASA master Directory
http://pdssbn.astro.umd.edu/home.html	Small Solar System Bodies
http://ringside.arc.nasa.gov/www/rpx/viewer/rpx_viewer.html	Saturn Ring-plane crossing
http://rs560.cl.msu.edu/weather/interactive.html	Weather
http://seds.lpl.arizona.edu/pub/messier/Messier.html	Messier object images
http://seds.lpl.arizona.edu/pub/billa/tnp/nineplanets.html	Solar system tour
http://skyview.gsfc.nasa.gov/skyview.html	Skyview; map of sky in different wavelengths
http://spacelink.msfc.nasa.gov	NASA's Spacelink for news and images
http://stsci.edu/EPA/	Hubble Space Telescope
http://thunder.met.fsu.edu/~nsw	Weather
http://tycho.usno.navy.mil/what.html	Universal time
http://umbra.gsfc.nasa.gov/sdac.html	Solar images and eclipse bulletins
http://www.america.net/~erg/asa.html	Astronomical Society of the Atlantic
http://www.as.astro.utexas.edu/	McDonald Observatory
http://www.astrow.edu	OGLE dark-matter project status
http://www.c3.lanl.gov/~cjhamil/SolarSystem/homepage.html	Solar system tour
http://www.cea.berkeley.edu/Education/SII/pilot.html	Science On-Line; virtual museums
http://www.cea.berkeley.edu/HomePage.html	EUVE satellite information
http://www.crl.go.jp/CRL/Honsho/OpticalCenter/oao/oao.html	National Astronomy Observatory of Japan
http://www.darksky.org	International Dark-sky Association
http://www.digimark.net/galaxy	Jason Ware's astrophotos
http://www.exploratorium.edu	San Francisco's Exploratorium
http://www.fourmilab.ch/solar/solar.html	Solar system tour
http://www.fourmilab.ch/earthview/vplanet.html	Create views of Earth
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http://www.geo.mtu.edu/weather/aurora	Aurora report from Michigan Tech
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http://www.gsfc.nasa.gov/hqpao/newsroom.html	NASA news releases
http://www.gsfc.nasa.gov/NASA_homepage.html	NASA homepage
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http://www.hq.nasa.gov/office/pao/Newsroom/today.html	NASA news
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http://www.metrolink.com/seti/SETI.html	SETI info
http://www.mtpe.hq.nasa.gov/HQ_homepage.html	NASA headquarters
http://www.ncsa.uiuc.edu/General/NCSAExhibits.html	Cosmology images and animations
http://www.ngdc.noaa.gov	Solar activity data sets
http://www.noao.edu/noao.html	National Optical Astronomy Observatories
http://www.noao.edu/galileo	Galileo spacecraft information
http://www.nrl.navy.gov/clementine/clib	Clementine images
http://www.physics.sfsu.edu/asp/asp.html	Astronomical Society of the Pacific
http://www.rahul.net/resource	Astronet newsletter
http://www.sel.bldrdoc.gov/today.html	Solar image for today
http://www.sel.noaa.gov/images/solar_sites.html	Daily Sun images
http://www.stsci.edu/top.html	Space Telescope Information Service
http://www.stsci.edu/EPA/Recent.html	Recent Hubble Space Telescope results
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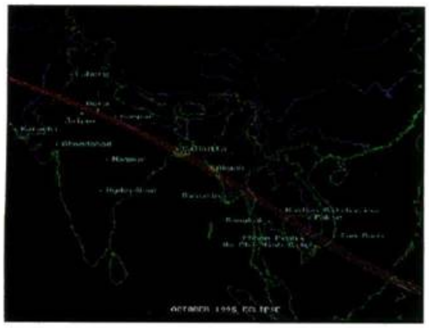

***EclipseComplete*, program by Zephyr Services**

optics, including those of advanced apochromatic and catadioptric scopes.

Special-purpose programs aren't just for armchair astronomers. Lots of programs provide crucial information to observers wanting to know, for example, when to observe Jupiter's Red Spot, a place on Mars, or the moons of the planets. Other programs maintain and access observing logs. Yet others determine the times when the Moon or an asteroid may occult, or pass in front of, a bright star as seen from a given location.

Astrophotographers can use special-purpose programs to calculate exposure times for different types of objects. These programs can also tell how much sky a lens or telescope-eyepiece combination will cover. They even go so far as to help determine the eyepiece's field of view and which eyepiece will split a close double star. Another program will determine the position of an object in a photograph.

To observe satellites, a multitude of programs track the orbits of the space shuttle and other Earth satellites. These programs list when and where to see these objects as they race across the sky.

For a break from the thoughtful side of astronomy, relax with astronomically oriented games. If you haven't done so already, put away that planetarium program for a while and let some special-purpose programs strut their stuff.

Path to the Future

Planetarium and special purpose programs are great for showing what's in sky. But to catch up on the latest news from the Hubble Space Telescope or to learn about the latest supernova, you need access to the Information Superhighway.

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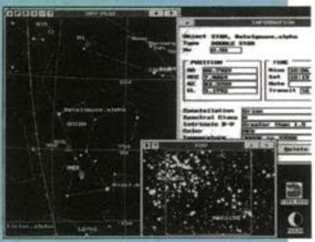

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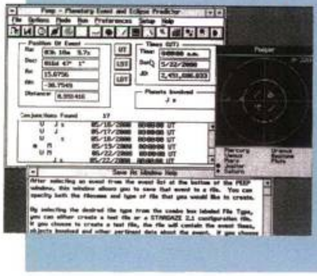

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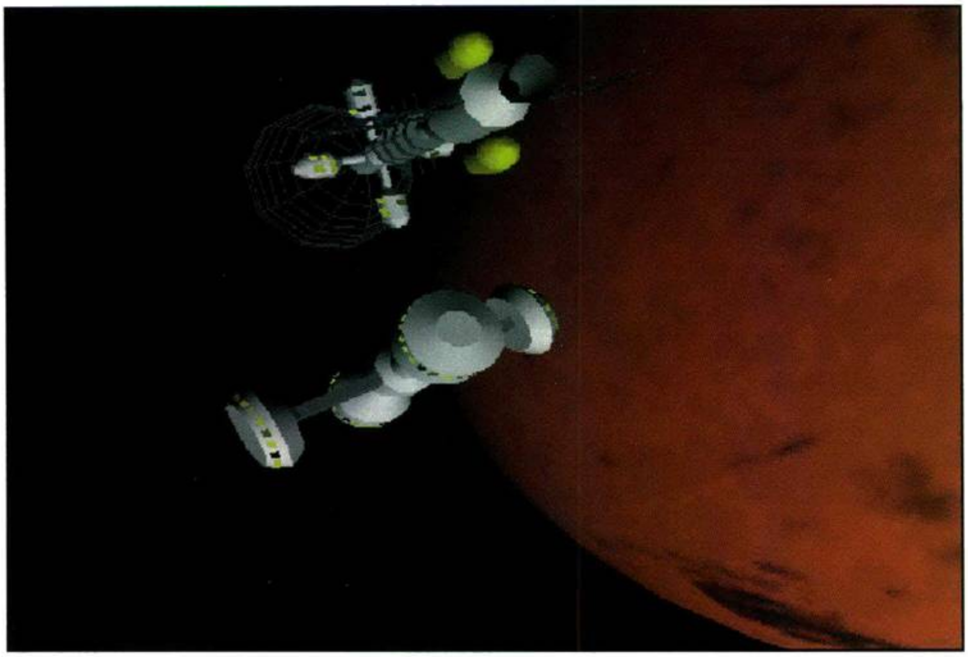
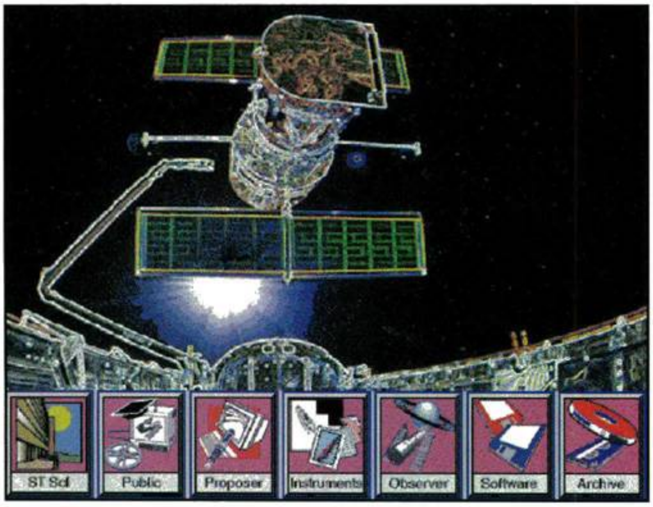


***Space Simulator*, program by Microsoft**



Hubble Space Telescope home page on the World Wide Web, at http://www.stsci.edu/top.html

computer up to the Net. Individual users usually rent a connection to the network through an Internet provider. On-line computer services such as America Online and Delphi are common providers for home computer owners. They have a computer tied directly into the Internet. Customers use a modem to dial into this computer to link into the Net. (For more information, see "Blasting Along the Infobahn" in the June 1995 ASTRONOMY.)

The most popular way to cruise along the Internet is through the World Wide Web. The Web links text, sound, images, movies, and programs together without users having to know on which computers these files are stored. For example, in a Web document about stars, the word supernova might be highlighted or underlined. Merely clicking on the word could bring up the latest image of Supernova 1987A or a list of recent supernovae. Viewers remain unaware of the fact that the computer automatically retrieved the image from a Space Telescope Science Institute computer in Maryland or the list from a computer in Australia.

To access Web resources, you utilize a program such as *Mosaic* or *Netscape*. A great place to start exploring is ASTRONOMY's home page. To get there, open the document's address, also called a Uniform Resource Locator, which is **http://www.kalmbach.com/astro/astronomy.html** ("http://" identifies the type of document, www.kalmbach.com identifies the computer, and the rest identifies the file name and folder).

When retrieving information from the Web, pay attention to copyrights and fair-use agreements. Web cruisers can download much of it freely, as long as they obey applicable copyright notices and ownership information. But a lot of it is not for recirculation, even though users may easily download it. Shareware programs typically have a 30-day period during which users can try out the software for free; after that, they must pay for its use.

Whether you browse the Web or explore the sky using commercially available programs, you'll find that computers can greatly enhance your enjoyment of the hobby.

Adobe Systems Inc., 1585 Charleston Road, Mountain View, CA 94039-7900, (800) 833-6687

Aladdin Software, 1001 Colfax Street, Danville, IL 61832, (217) 443-4611

Algol Software Works, P.O. Box 6714, Orange, CA 92613

Altair Engineering, P.O. Box 301, Loma Linda, CA 92354, (800) 984-4545

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ARC Science Simulations, Box 1955A, Loveland, CO 80539, (907) 663-3223, fax (907) 667-1105

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Axiom Research, Inc., 1304 East Eighth Street, Tucson, AZ 85719, (602) 791-2864

Richard Berry, 22614 N. Santiam Highway, Lyons, OR 97358, phone/fax (503) 859-3030

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National Space Science Data Center, Code 633, Goddard Space Flight Center, Greenbelt, MD 20771, (301) 286-6695, fax (301) 286-1635, e-mail request@nssdca.gsfc.nasa.gov

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NRSpace Software, P.O. Box 30864, Seattle, WA 98103, (800) 548-7766, fax (206) 783-9296

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Palo Alto Software, 2641 Columbia St., Eugene, OR 97403, (503) 683-6162, fax (503) 683-6250

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Parsec Software, 1949 Blair Loop Road, Danville, VA 24541, (804) 822-1179

Parsec Technology, 4323 N. 30th St., Boulder, CO 80301, (303) 447-0071

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Physics Academic Software, TASL, Box 8202, North Carolina State University, Raleigh, NC 27695-8202, (800) 955-8275, fax (919) 515-2682

picoScience, 41512 Chadbourne Drive, Fremont, CA 94539, (510) 498-1095

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Project CLEA, Dept. of Physics, Gettysburg College, Gettysburg, PA 17325, (717) 337-6028; also see the Web Sites table

Project Pluto, Ridge Road, Box 1607, Bowdoinham, ME 04008, (207) 666-5750, fax (207) 666-3149

Robert Ridky, Geology Department, University of Maryland, College Park, MD 20742

Saguaro Astronomy Club Database, A.J. Crayon, 13819 N. 37th Avenue, Phoenix, AZ 85023

Sehgal Corp., 1776 Windflower Way, Gloucester, ON K1C 5Y9, Canada, (613) 794-1134, fax (613) 837-3011

Science Lab Software, 93 Albemarle Road, Norwood, MA 02062, (617) 769-5153, fax (617) 769-2158

Science.wks, 42 Fletcher St., Winchester, MA 01890, phone/fax (617) 729-2630

Seattle Support Group, 20420 84th Ave. So., Kent, WA 98032

Software Systems Consulting, 615 W. El Camino Real, San Clemente, CA 92672, (714) 498-5784, fax (714) 498-0568

Software Bisque, 912 12th Street, Suite A, Golden, CO 80401, (303) 278-4478, fax (303) 278-0045

SoftKey, 201 Broadway, Cambridge, MA 02139, (617) 494-1200, fax (617) 494-1219

Southern Stars Software, 12525 Saratoga Creek Drive, Saratoga, CA 95070, (408) 973-1016

Spectra Astro Systems, 6631 Wilbur Ave., Suite 30, Reseda, CA 91335, (800) 735-1352, fax (818) 996-7698

Stellar Software, P.O. Box 10183, Berkeley, CA 94709, (510) 845-8405, fax (510) 845-2139

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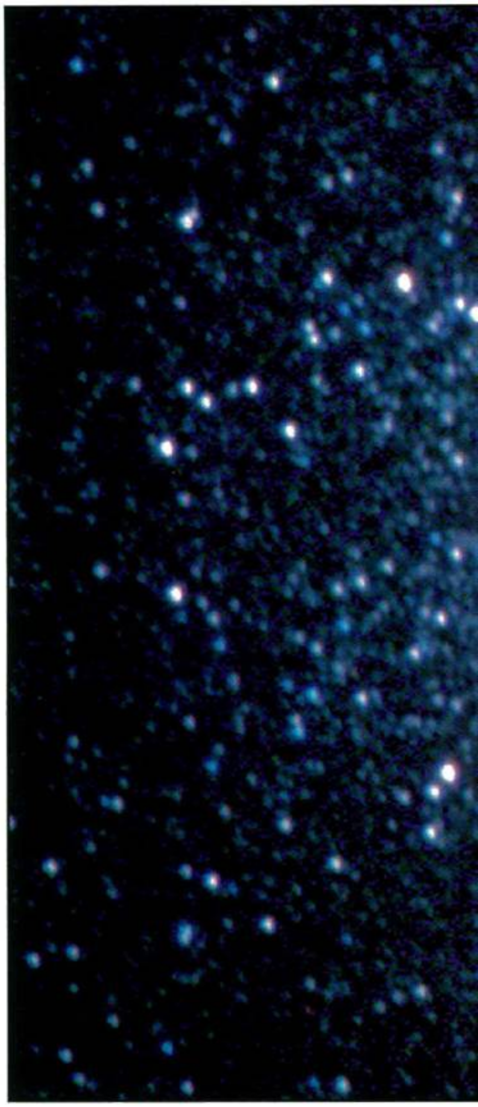
Shooting the Sky With an Electronic Camera

by Richard Berry

CCD cameras give backyard astronomers a powerful new tool for exploring the universe.

Is there one in your future?



Over the tiny observatory, a million stars burn silently against the coal-black firmament. In the dome the clatter of keystrokes and the hum of small motors emerge to form a continuum of background sound. Beside the telescope two astronomers confer in reverent whispers. On the screen of the computer before them, flickering numerals count off the remaining seconds.

"Boo-beep!" The tiny dome fills with a silverish glow as an image scrolls onto the screen. Fingers reach toward the screen; there are whispered exclamations. "We've got it," one says, "We've got Chiron. Look at that glow around it. Could that be its coma?"

In the coming decade, scenes like this will play out in backyard observatories around the world. In countless family rooms adjoining suburban patios, eager eyes will watch as galaxies and star clusters and asteroids slither across computer screens. On a scale never before known, curious human beings will scan the heavens, seeking to see deeper into the mysteries of the cosmos. And many of those watching will be amateur astronomers.

Behind this revolution in amateur astronomy is a remarkably simple electronic device: the charge coupled device, or CCD. It's a spinoff from computer technology, a chip of silicon that senses light, an ultra-sensitive electronic sensor that replaces the eyepiece on the back end of your telescope.

Before getting too far into the revolution, realize that CCD astronomy is in its infancy. The field is developing rapidly, and just as in the early days of astrophotography, a large, ever-changing world of strange new terms and ideas is emerging. Don't let this jungle of jargon scare you: as you get to know CCDs and as time passes, these strange terms will become as familiar as the words emulsion, ISO number, and silver halide are today.

CCDs offer some remarkably useful qualities. The human eye and the silicon chip have approximately the same sensitivity to colored light. Something like half the photons that fall on the retina are converted into a useful signal in the eye. The silicon responds to a slightly higher percentage — perhaps 60 or 70 percent. The eye and the CCD rank close in native sensitivity; the big difference between them is that the human eye collects light for only about one-tenth of a second before passing a signal on to the brain.

The CCD can do that, but it can also record a faint source of light for one second, ten seconds, a minute, or an hour. Thus when the signal from a CCD goes into the computer, the image may have had 10, 100, 600, or 36,000 times longer to build than it would on a human retina. No wonder the CCD sees so much more than the eye: it has time on its side.

You can't use a CCD chip by itself, of course. It needs electronics to control its operation, read out accumulated electrons, amplify them into a signal voltage, and convert the voltage to numbers. It then needs a computer to receive and display the digitized image. The CCD chip must be housed securely, kept cold, and massaged with all the right voltages. Collectively, the housing and electronics is called a CCD camera. The camera at-

CCD, charge-coupled device. A light-sensitive silicon chip that creates an image that can be stored and manipulated by a computer.

The Hercules Cluster

by Jack Newton
(25-inch f/5 reflector, SBIG ST-8 CCD camera)

Pixel. Shorthand for picture element, the "dots" that make up a CCD image. Similar to silver grains in a photo emulsion.

taches to the telescope where the eyepiece would normally go. The telescope becomes a huge lens focusing light on the CCD chip.

CCD cameras also offer some advantages over conventional photographic cameras. The ability to process the images digitally means the age of the messy, chemical-strewn darkroom are over. Your computer is now your darkroom, and altering the image becomes as easy as a few clicks of the mouse button. A digital image, being a group of discrete numbers, captures light in a more precise way than a conventional photographic image does. And as CCD chips become larger and less expensive, their resolution will challenge conventional photography, particularly with wide-field images.

The required electronics are quite simple: for a few hundred dollars in parts and a month or two of spare-time, anyone interested can build a CCD camera. For those who like turnkey systems, the market now offers a truly remarkable choice of ready-made CCD cameras.

Digital Imaging Basics

Digital imaging comes with an exotic new vocabulary. Yet the basic ideas behind it are very simple. In a digital image, the picture is divided into a large number of picture elements, or pixels. Each pixel is like one tile in a mosaic. It has a number that locates it in the grid and a numerical value that corresponds to the amount of light falling on it during the exposure. And just like the tiles in a mosiac, when you put enough pixels together, you have a picture.

None of the CCD chips in widespread use by amateurs were designed for astronomy. Research-grade CCDs cost many thousands of dollars. Instead, amateurs depend on the high-quality CCD chips mass-produced for top notch video cameras and commercial-grade digital imaging systems. Although the trend is toward larger and larger CCDs, it takes only a modest number of pixels to make useful images. In amateur astronomy, the digital imaging revolution began when CCD cameras attained 165 lines of 192 pixels each, for a total of 31,680 pixels.

Dark current. Electronic noise created by a CCD camera. It must be subtracted to get a clean, true image of the sky.

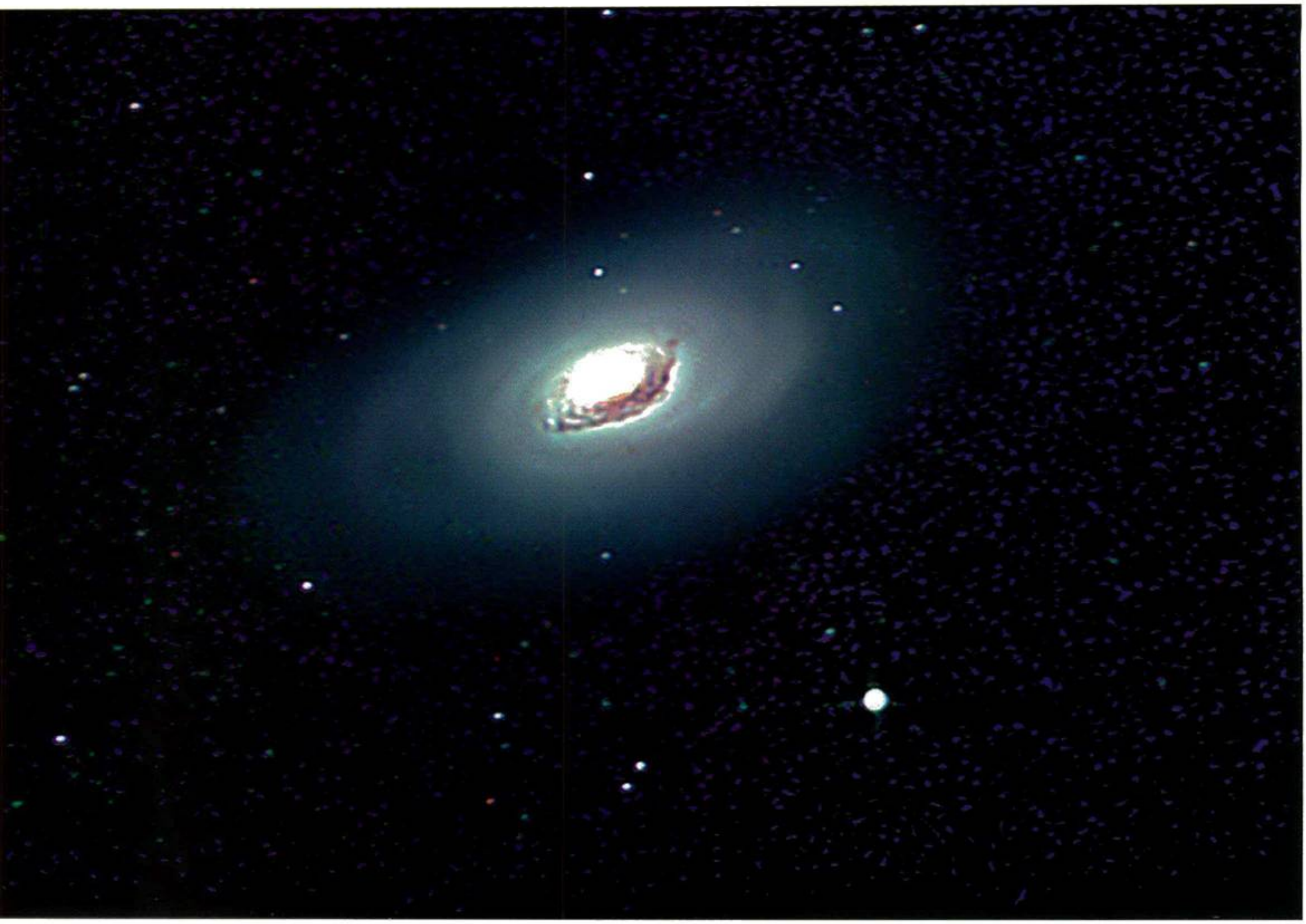
Making the Image Right: Calibration

No CCD chip is perfect. Each has its own distinct peculiarities that affect the images it takes. Fortunately for the CCD sky shooter, it's possible to retroactively adjust the numbers to create an image in which the response of every pixel appears identical. This process is called calibration.

Calibration involves correcting for two effects: dark current and nonuniformity. Consider dark current first. Recall that CCDs make an image by accumulating electrons over some period of time, a few seconds to a few hours. To a greater or lesser degree, all CCDs generate electrons on their own whether they are exposed to light or kept in total darkness. This is called the dark current. No two pixels have precisely the same dark current. Cooling the CCD to a temperature around –22° F (–30° C) reduces the dark current but doesn't eliminate it.

Flat-fielding. A process of subtracting image artifacts to improve the CCD image.

Because the dark current is different for every pixel, it makes the image look coarse and grainy. (If you've ever seen terrible-looking CCD images, it might be that some observer forgot to subtract his dark image.) But it's easy to subtract the dark current. Several times during the night, CCD observers cap their telescopes so that no light enters and make "dark frame" images to record the dark current. Later, they average the dark frames together to create a master map of dark current and then they subtract this from the night's images, neatly eliminating one of the peculiarities of the CCD. It works because subtraction is easy with images made of



The Blackeye Galaxy

by Jack Newton
(25-inch f/5 reflector, Meade Pictor 1616 CCD camera)

numbers.

A second peculiarity of CCD chips also needs correcting. CCDs are not perfectly uniform in their sensitivity to light. Some parts of the chip are more sensitive than others. The variation in light sensitivity is small, typically just a few percent. But when an astrophotographer is looking to capture faint galaxies against a light-polluted sky, the nonuniformity in the CCD may overwhelm the tenuous glow of a galaxy. To correct this, careful observers shoot flat-field frames. They take a picture of a glowing screen attached to the front of the telescope. (Sometimes they use the twilight sky.) Done properly, the flat-field frame precisely maps the CCD's nonuniformity. This allows the photographer to remove its effects from the image. Once again, this is easy to do with an image made up of numbers.

Calibrating a CCD image consists of removing the dark current and flat-field errors to make the image a true picture of what the CCD camera "saw" in the sky.

Proper calibration is the *sine qua non* of good CCD imaging. After dark current is subtracted and the image has been carefully flat-fielded, the resulting CCD image is an accurate digital record of the light that entered the telescope and fell on a waiting CCD, a bit of sky captured onto the hard drive of your computer.

Looking at Images

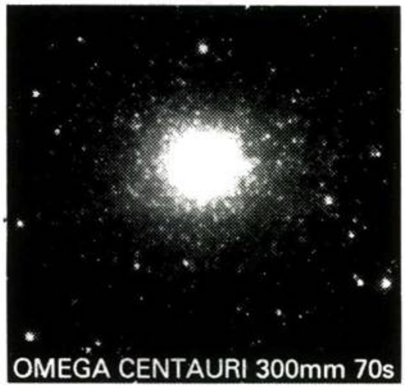
CCD images are made of numbers, and every image contains a wealth of data. But data by itself has no value until it is analyzed.

To see what this entails, let's look at the numbers in a typical calibrated image. Suppose we find that the pixels in the average sky background have a value of about 100. The spiral arms of a galaxy have values that begin as low as the background sky and rise to 110, 125, even 200 in some their brighter knots. The nucleus, by far the brightest part of most galaxies, peaks at about 600, and a few pixels in surrounding stars have values of 2,500 or even higher. (Depending on the type of CCD, the highest possible pixel value may be 255, 4,095, 16,383, or even 65,535.)

Linear scaling is a simple image processing technique that increases contrast in an image.

The values you see in the image are but a small part of the possible range of values. To turn these values into an image, you must scale the numbers, that is, adjust their values so that the sky background appears dark gray or black and the brightest parts of the galaxy appear light gray or white.

Here is where digital image process-



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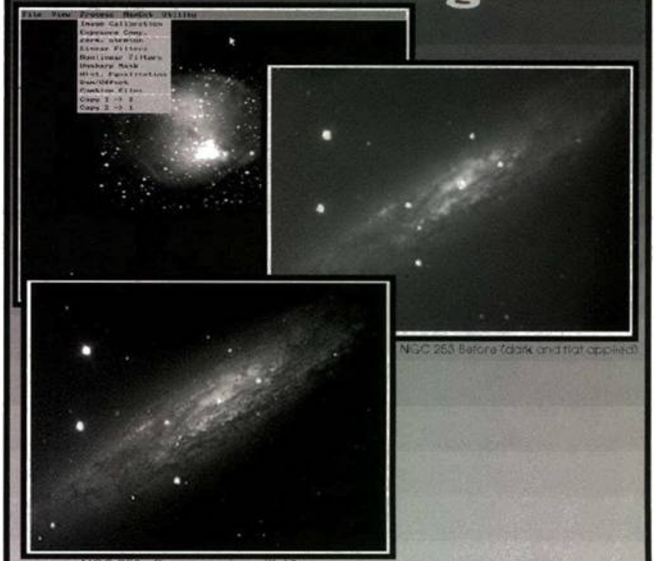

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NGC 253 image by Glenn Gombert & John Chumack ST-6 Camera

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Logarithmic scaling. A more sophisticated image processing technique used to bring out details in extremely faint objects.

ing comes in. With a computer to do the number crunching for you, you can select any pixel value that you want as black and any other you want as white and let the computer transform and display the image on the computer screen. Even if digital image processing sounds like magic, remember that it's simply a set of computer tools for teasing information from arrays of numbers. The goal of digital image processing is to reveal everything there is to see in an image.

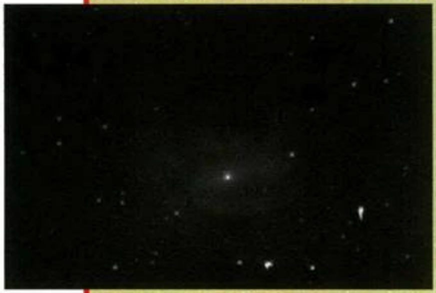
Brightness Scaling

In our daily lives human beings are most comfortable viewing scenes that vary by a factor of about 30 from the brightest highlights to the darkest shadows. When the brightness range departs greatly from this, our eyes begin to strain. For example, dense fog reduces the world to a single shade of gray and we find it hard to distinguish objects from each other. At the other extreme, harsh lighting pushes the contrast too high, and our world fills with inky shadows and glaring highlights. Our eyes have adapted to see best over a 30-to-1 brightness range.

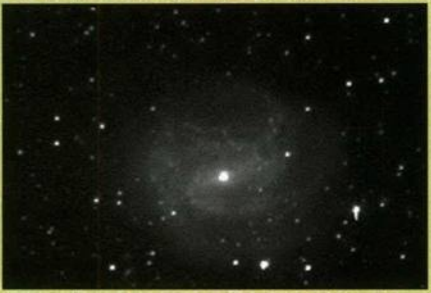
Celestial scenes seldom meet this criterion. Stars glare brilliantly against the blackness of the night sky, while the extended haloes of bright galaxies are thousands of times fainter than the nuclei of those same galaxies, so they all but disappear in skyglow. To see these objects, we need to display them in a way that does not push our vision, or our computer monitors, beyond what's comfortable. To do this, we must rethink how

Scaling and Enhancing

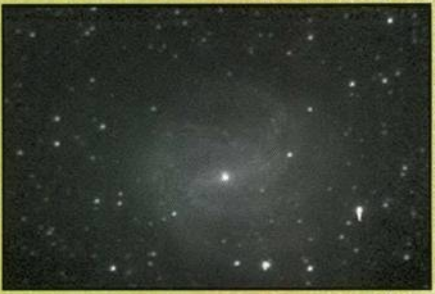
This series of the galaxy M83 illustrates the effects of scaling and image enhancement. Images by Steven Lee (8-inch reflector, Cookbook 245 camera).



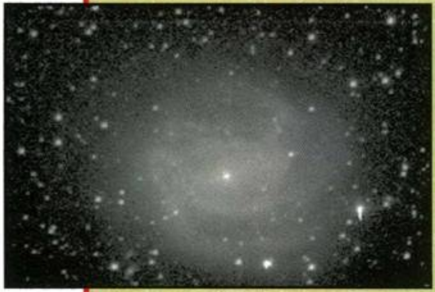
The full dynamic range: too dark.



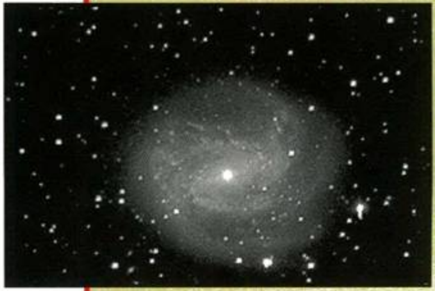
Linear scaling: the faint areas are too dark.



Gamma scaling: details retained in bright regions and moderately bright areas



Logarithmic scaling: pulls up background details while retaining definition in the highlights.



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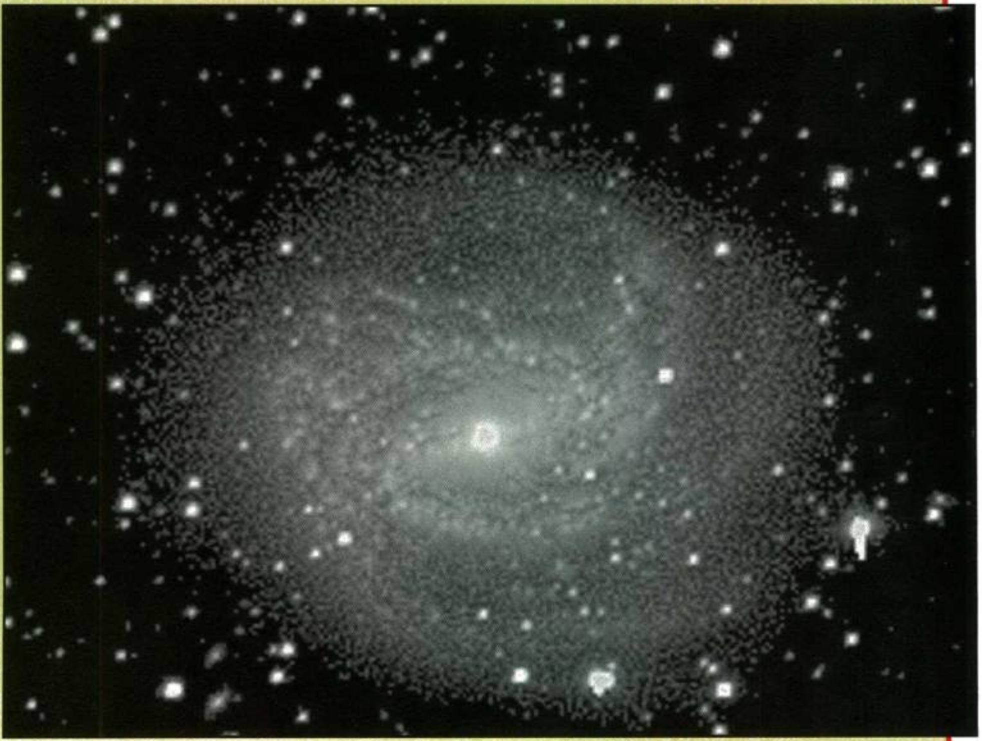

The Lucy-Richardson algorithm plus a contrast-stretch enhances the small-scale structures in the galaxy.

to display the pixel values in an image.

Let's consider again our sample galaxy image. With our particular CCD chip, the values that any pixel can have falls in the range of 0 to 65,535. On this scale, we saw that the average pixel value of the sky background is 100. The outer spiral arms of the galaxy blend into the sky with average values of 101 or 102, while the pixels that make up the nucleus of the galaxy have values of 600, much brighter than the sky. Lastly, a few field stars sparkle brightly with pixel values over 2,500.

If we displayed the full range of brightness in the image, we'd see only the brightest stars. The fainter stars and the galaxy's spiral arms lie at the very bottom of the monitor's range of brightness. The information is there but it's invisible.

To improve the image, we can perform a transfer function called linear scaling. This process uniformly "stretches" the scale of gray values between two chosen values, let's say between100 and 600 in this case. (The process is called linear scaling because on a graph showing input pixel values versus output pixel values, the scaling makes a straight line.)

How's it look? Well, not too good: the galaxy still appears much too dark. The nucleus is white, but the arms are dark gray and the sky is jet black.

So let's retry the linear scaling, only this time we'll set the value of 85 as black and 200 as white. The spiral arms now spread against a salt-and-pepper gray sky, but the bright inner regions of the galaxy are burned-out white. On the whole, though, the image now looks pretty realistic — because we have grown used to seeing galaxies in photographs with burned-out nuclei and stub-arms set against a jet-black sky.

Gamma scaling. A more sophisticated image processing technique that separates middle tones in an image.

But with digital image processing, we don't have to stop here. It's no longer necessary to settle for such a crude representation of the real galaxy.

Nonlinear Scaling

What's needed is a more sophisticated kind of brightness scaling, one that separates the values in the dark parts of the image and compresses the values in the brighter parts of the image. The answer is called gamma scaling.

In gamma scaling, the transfer function is a gently bowed curve instead of a straight line. Gamma is a number that

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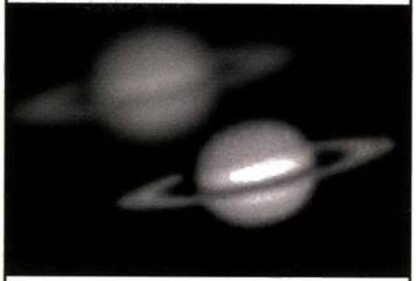

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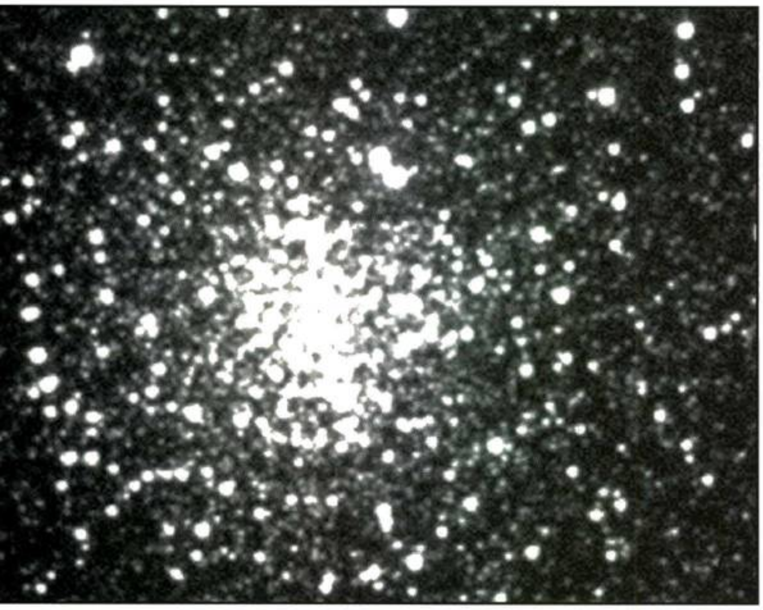
Spiral Galaxy M101

by Jack Newton
(25-inch f/5 reflector, Meade Pictor 1616 CCD camera)



Globular Cluster M4

by Pedro Ré
(14-inch SCT at f/7, Hi-SIS22 CCD camera)

describes how strongly bowed the curve is, and whether it bows upward to enhance deep-sky objects or downward to give more snap to images of the Moon and planets.

If gamma is greater than one, then the slope of the curve is steep at low pixel values and shallow at high pixel values, so galaxies come alive. Glowing spiral arms reach out and wrap inward to a tiny intense point of the nucleus.

Logarithmic scaling is an even more potent type of nonlinear scaling. It resembles gamma scaling in having a curved transfer function, but its curve rises very steeply at low pixel values and provides extreme enhancement of faint deep-sky objects at the bottom end of the brightness range.

Digital Sharpness Enhancement

Contrast control is wonderful, but if there is anything really magical in image processing, it's spatial enhancement. Images that start out soft and fuzzy become crisp and sharp as you watch. Tiny lunar craters, spiral arm starclouds, Martian dust storms, and galactic dust lanes emerge from images that once appeared soft and blurry.

Two broad approaches to spatial enhancement are in use today: unsharp masking and iterative deconvolution. Unsharp masking is generally a bit better for lunar, planetary, and solar images, while iterative deconvolution holds the edge for images with stars.

Unsharp masking selectively enhances the contrast of the fine structures in an image. To see how it works, imagine that all the features in an image fall into just two classes: big features and small ones. Large features are easy to spot, but small features are hard to see. In effect, you need to increase the visibility of the little features while holding the big ones more or less unchanged. Unsharp masking does the trick.

Here's how it works. Start by making a blurry copy of the original by averaging the value of each pixel with the values of the pixels around it. In the blurry copy, large features remain visible because they span many pixels, while small features only a few pixels across disappear. The result is a blurry copy of the original with its small details removed.

Now multiply each pixel value in the original image by an enhancement factor (for example 3), and multiply the blurry copy by a smaller factor (let's say 2). Then subtract the blurry image from the original.

Unsharp masking. A powerful image processing technique that sharpens details in images of extended objects such as planets

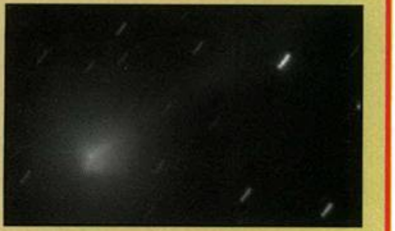
The result is almost magic. Large features are hardly altered. Multiplied by 3 and subtracted by 2, they undergo little change. The story is very different for the small features, however. These were multiplied by 3 in the original, but because they were not present in the blurry copy, the 3x multiplcation remains after the blurry copy is subtracted. The result? Small features have become three times more intense. Unsharp masking leaves large features unchanged but triples the visibility of the small features — and does it in a few seconds of computer time.

Iterative Deconvolution

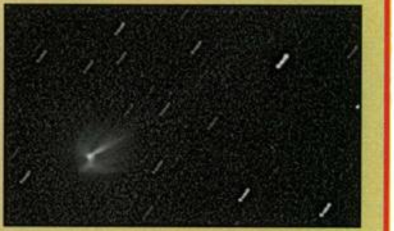
The term *"iterative deconvolution"* covers a wide range of computer enhancements. But all hinge on the same

Extracting Detail

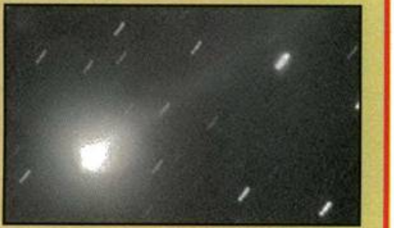
This series of Comet Machholz 2 shows how much detail lies hidden in a digital picture. Images by Jerry Armstrong (16-inch Cassegrain, SBIG ST-6 CCD camera).



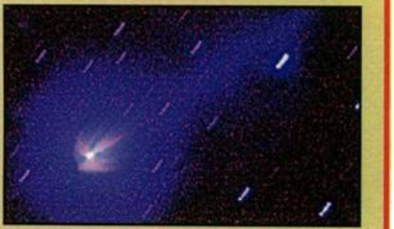
Adaptive scaling: shows the comet acrsos the full dynamic range of brightness.



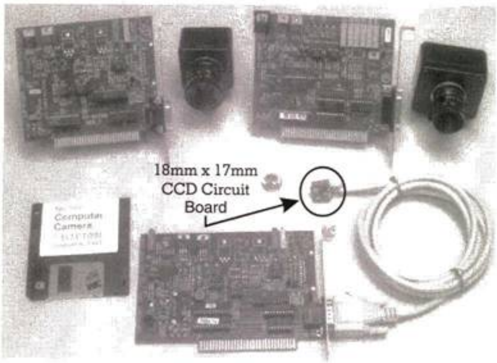
Deep processing: brings out jets in the comet's coma and faint background stars.



Scaling for faint detail: low-luminosity parts of the comet come to life, including the halo surrounding the nucleus.



Pseudo-color processing: provides colors coded with different spatial and intensity processing. Blue is faint detail, red is fine-scale structure, and green is overall light from the comet.



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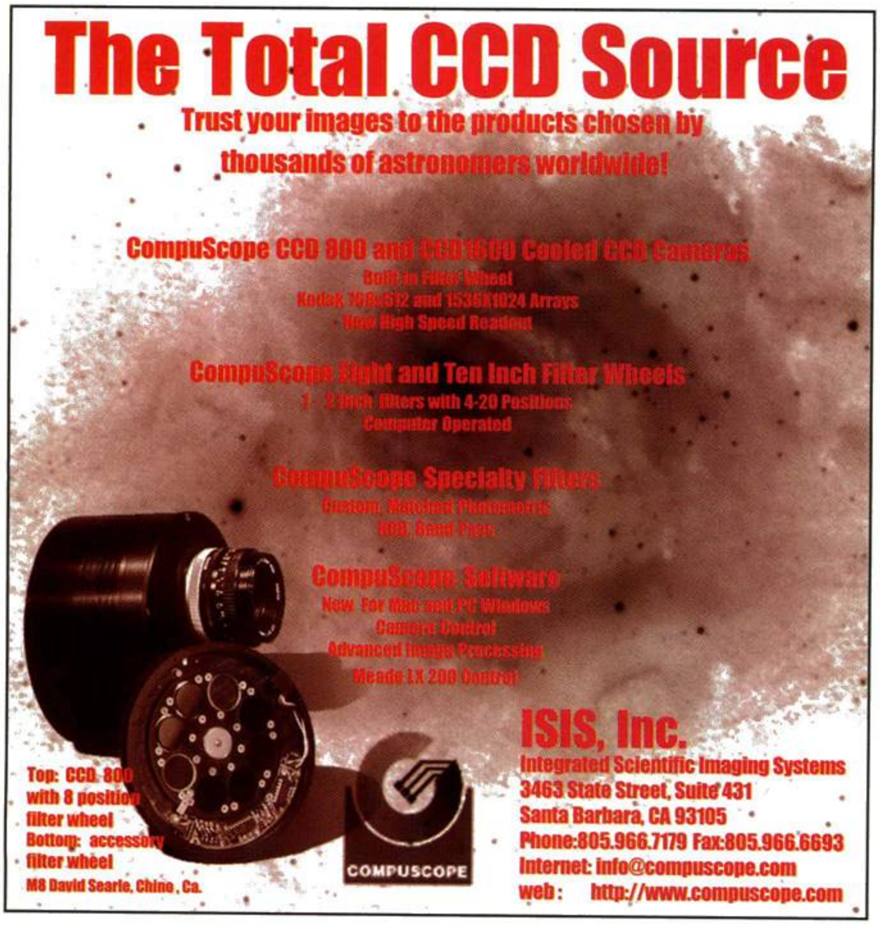

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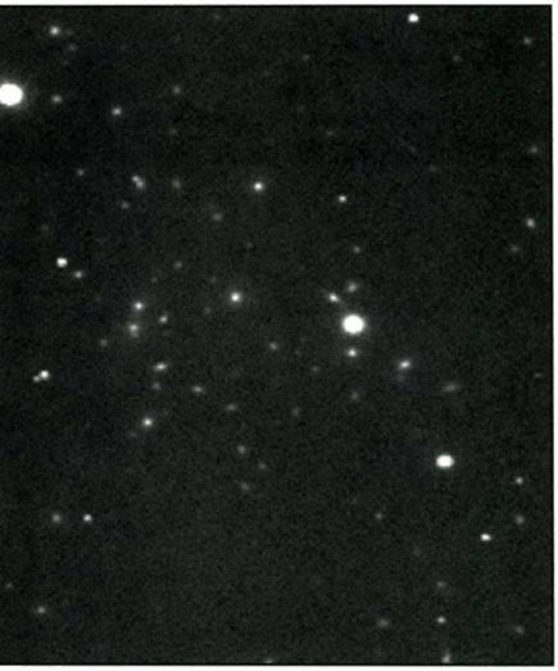
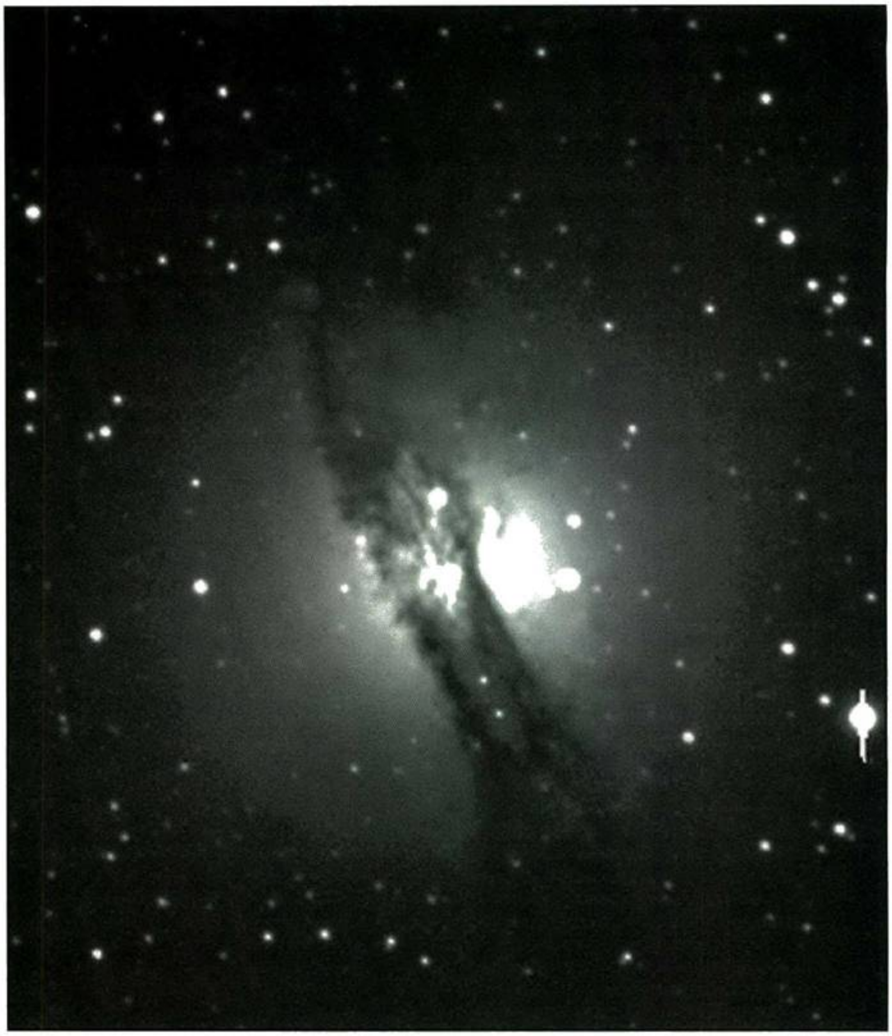


The Corona Borealis Galaxy Cluster

by Jerry Armstrong and Tim Puckett
(16-inch f/6 reflector, SBIG ST-6 CCD camera)



Peculiar Galaxy Centaurus A

by David Hanon
(7-inch f/9 refractor, SBIG ST-7 CCD camera)

basic idea: use a repeating (iterative) computational search to find what the image looked like before the atmosphere and telescope optics blurred it.

When you run an iterative deconvolution program, you can watch the image become sharper and sharper with each iteration. At some point, the process either "converges" and the image stays the same without further improvement, or the process "diverges" and the image gets weirder and weirder. It may take as few as five iterations or dozens of them, at 60 seconds per iteration, to process an image. Although it demands a lot of computer time, when the original data is high, the enhanced image can be pretty amazing.

The Spirit of Inquiry

Every CCD image holds a wealth of information. After calibration, it's a piece of sky captured in numbers. That means you can, if you choose, go way beyond capturing pretty portraits of your favorite sky objects. You can do something that contributes to science. From a calibrated image you can extract the precise positions of a star, the magnitudes of any star (or a cluster of them), and the total light of extended objects such as galaxies. Extracting specific types of information is called image analysis.

Image analysis is usually most effective on images that have been calibrated but otherwise not processed. Such an image consists of pixels whose numerical values precisely reflect the amount of light that fell on the CCD chip. It's an exact digital copy of the real sky. To derive the information that you want, you use several kinds of image analysis software to create "virtual instruments" to examine the image.

Astrometry: Measuring Positions

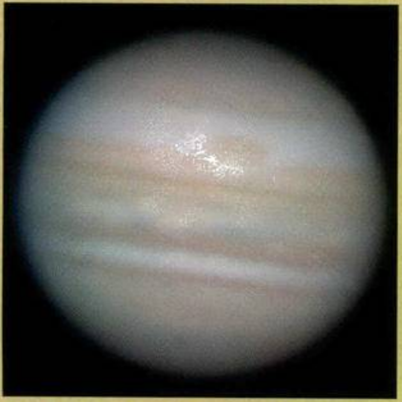
For nearly a century, astronomers measured the positions of stars by placing a photographic plate on the carriage of a precise measuring engine and carefully bisecting the stellar image with the crosshairs in a viewing microscope. It was possible, with great care, to measure the position of a star image within 0.001 millimeter.

Iterative deconvolution. Image processing to sharpen images of stars. Techniques that apply a repetitive step of enhancement to an image to sharpen it and boost contrast.

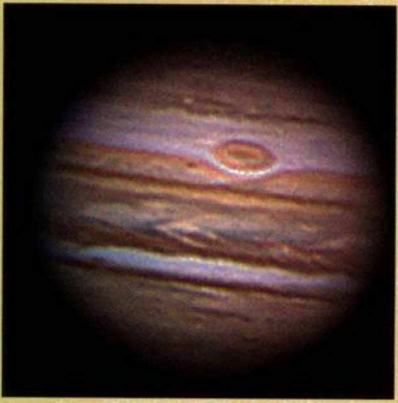
Position measurement with CCDs is easy because pixels are etched very precisely on the CCD chip. When you designate a particular star, the "virtual measuring engine" in the software finds the center of the stellar image to a few hundredths of a pixel — about 0.001 millimeter — in a fraction of a second. Given the positions of three or more stars in a CCD image and their catalogued celestial coordinates, the software can easily determine the coordinates of any star, asteroid, or comet in the image. Armed with a 6-inch telescope, a CCD camera, astrometric software, and the *Hubble Guide Star Catalog* on CD-ROM, any backyard astronomer can, for example, report the location of newly discovered comets and asteroids within one-half arcsecond — accurate enough to catch the interest of professional astronomers.

Unsharp Masking

This pair of Jupiter images shows how effective unsharp masking is in extracting structure from planetary portraits. Images by Donald C. Parker (16-inch f/6 reflector, SpectraSource Lynxx-PC CCD camera).



The original image: straight from the camera, it shows little detail.



Unsharp masking: two passes through this filter improve contrast and punch up details.

Photometry: Measuring Brightness

Since the 1940s, professional astronomers have measured the brightness of stars by means of a photometer. The process is fairly laborious. They place each star in the aperture of the instrument and measure the light of the star and the background sky using the instrument's photomultiplier tube. They then measure the brightness of the sky in a nearby starless region. The light contributed by the star alone is taken as the difference between the two measurements. Operational difficulties such as identifying the stars and centering the telescope on them, tracking, and atmospheric transparency and seeing all place severe limits on the amount and precision of such photometry.

With digital images, however, the "virtual photometer" can be used in a warm, comfortable location, aiding the digital observer in recognizing star fields and largely eliminating variations in seeing, tracking, and transparency. The technique of measurement, however, is much the same. The observer designates the star of interest, and the software sums the values of all the pixels in the stellar image, and also sums the values of pixels in an equally large starless region nearby. The star's contribution is the difference between the two measurements. From well-calibrated images, the brightness of stars can be measured to 0.01 magnitude. At this level of precision, such measurements have real value for astronomy.

A Digital Future

The CCD camera opens many doors for amateur astronomers. For those who wish to go beyond the Messier catalog, search for new asteroids, measure the slow movement of the nearby stars, and trace variable stars as they cycle in brightness, the CCD offers a universe you can quantify. For those who wish to see fainter, deeper, and farther than possible by eye, the CCD offers a universe of discovery. For those who wish to search for clouds on Mars, monitor the belts of Jupiter, and watch for storms on Saturn, enhanced CCD images offer a sharper, clearer vision than ever before.

CCD cameras do not mean that backyard astronomers must forego the traditional pleasures of visual observing. It only means that astronomy now offers more options than ever before. For me, and I suspect for most amateur astronomers, the CCD and the computer seemed alien at first to what amateur astronomy is all about.

The longer I have worked with CCDs, however, the more convinced I have become the very opposite is true. CCDs and digital image processing give us sharper eyes and deeper powers than ever before to observe the universe, to see, to measure, and to understand everything that is out there.

Richard Berry is a freelance astronomy writer and lecturer living in Lyons, Oregon. He is the author of the CCD Camera Cookbook *and* Build Your Own Telescope.

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Capture the Sky on Film

by Mark J. Coco

Shooting sky objects is easier than you might think.

There's nothing quite like heading off to the photofinisher to pick up your own roll of night sky pictures. It's so satisfying to pick the slides out of the box, thumb through the prints, and see those silvery images of the Moon or gauzy, reddish swaths of nebula that you created with your own camera. Photographing the stars lets you collect a personal archive of the universe as you've actually experienced it. It's a powerful way to enjoy this hobby of celebrating our place in the universe.

Taking pictures of the night sky is easier than you might imagine, too. It can be as simple as mounting a camera on a tripod, loading the camera with fast color film, and opening the shutter for a minute or two. This approach will net colorful pictures of constellations, aurorae, star trails, or close passages of the Moon by planets and stars.

More involved techniques permit recording starry fields of the Milky Way, closeup portraits of the Moon and planets, the faint spiral arms of galaxies, and glittering globes of stars halfway across the Galaxy. In backyard astrophotography, you can go as far as the desire, equipment, and techniques allow.

Collecting Constellations

The easiest way to start is to capture a constellation. Use a 35mm SLR camera and attach it to a sturdy tripod that will not vibrate as you open the shutter with a cable release. Make sure the camera contains fast color film, at least ISO 400 and preferably faster. Open the aperture as wide as possible and focus the camera on the stars. Look through the camera's viewfinder to compose a pretty scene with a constellation or two above the horizon.

Bracket the exposures to see which work best. Depending on the lens and film, try a 20-, 30-, 40-, or even 50-second exposure. The faster the film, the shorter the exposure you can use. (But be sure to give longer exposures a try, too. The results can be interesting — and there's seldom one "right" exposure anyway.) The shorter the focal length the lens has, the longer the exposure can be without trailing any stars. So when it comes to pinpoint star images, a 28mm lens enables longer exposures with less trailing than a 100mm lens.

Alan Dyer

CONSTELLATIONS ARE EASY TO PHOTOGRAPH. This portrait of Ursa Major and its Big Dipper asterism (upper right) was made with a camera set on a tripod and fast film. Photo by Alan Dyer.

To enhance constellation shots, include some foreground objects, whether they be trees, a stretch of horizon, an observatory dome, or a farmhouse. Compose the scene in the viewfinder as if it's a work of art.

Eclipses and Conjunctions

Eclipses and conjunctions offer great opportunities for skyshooters. Conjunctions occur when two astronomical objects pass close to each other in the sky, such as when the Moon approaches Venus or the planet Mars passes close to a bright star. Such events provide pretty scenes that are easily captured on fast color film. ASTRONOMY's Sky Guide (page 6) provides a good summary of the most impressive conjunctions of the year.

From time to time, the Sun and Moon produce eclipses. Lunar eclipses occur when the sun and Moon are on opposite sides of the sky and the Moon sneaks into Earth's shadow. Total lunar eclipses result when the shadow moves across the lunar surface and produces a darkened, reddened Moon. Try shooting with an 8mm to 2,000mm lens and bracketing exposures to record the ruddy face of the Moon.

A total solar eclipse occurs when the Moon covers part of the Sun's disk perfectly. Capture its image with anything from an 8mm to a 2,000mm lens. The best results come with focal lengths in the range of 800mm to 1,500mm and bracketing all the way — 1/2000 second to 1 second, depending on film speed. Use a wide-angle lens to record unusual foreground objects and the spooky darkness that surrounds eclipse watchers on the ground.

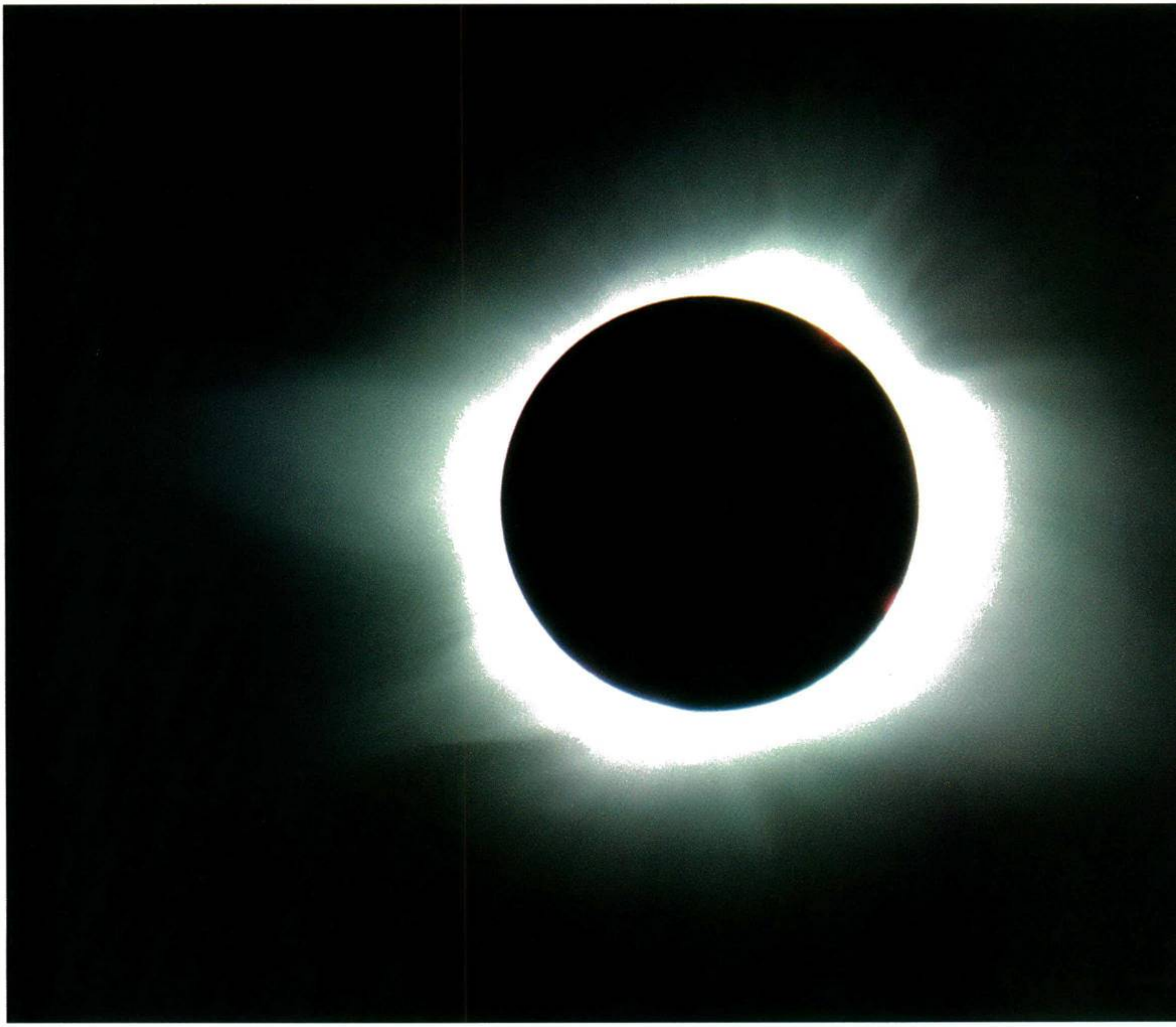
An annular eclipse takes place when the Moon is too far from Earth to cover the entire Sun and leaves a glowing ring of sunlight at maximum eclipse. Again, use any lens in the range of 8mm to 2,000mm and bracket a wide range of exposures to ensure some pleasing results. A partial solar eclipse results when the Moon skirts across part of the Sun's disk but doesn't cover it entirely.

Piggybacking

The next step in astrophotography requires a mount with an equatorial

PIGGYBACKED ON A TELESCOPE with a clock drive, a simple camera lens can record starlight over minutes or even hours. Luke Dodd employed a guided 55mm lens to capture the colors of Orion and Canis Major.

Luke Dodd



Andrew Steinbrecher

Donald C. Parker

PLANETS COME ALIVE with eyepiece projection, which magnifies their tiny images greatly. Donald C. Parker's photo shows Jupiter on December 20, 1984.

A SOLAR ECLIPSE offers one of the most beautiful events an astrophotographer can record. Andrew Steinbrecher's image depicts the eclipse visible from Mexico and Hawaii on July 11, 1991.

clock drive that tracks the stars across the sky. With this mount, attach a camera that rides piggybacked on the mount to dramatically increase the exposure time and at the same time avoid trailed stars. Properly polar aligned (see below), an equatorial mount permits shooting pinpoint stars and bringing out faint details that build up on the film over periods of a few minutes to an hour or more.

Piggybacking the camera opens up a whole new universe of subjects. Constellations now come alive with not only their brightest stars but also myriad faint ones filling the space in between. Patches of glowing gas and dark dust in the arch of the Milky Way paint the film like sprinkled chalk dust on a black canvas. Comets stand out with the bright centers and fuzzy tails against the backdrop of stars. Asteroids, small chunks of rock floating free in the solar system, reveal their presence by trailing against the background of pointlike stars.

PRIME-FOCUS ASTROPHOTOGRAPHY means attaching the camera to the telescope and using its long focal length for closeup pictures of galaxies and nebulae. Gerald Rhemann used a refractor to record the pinwheel-shaped galaxy M33 in Triangulum.

Shooting through the Scope

There's a more advanced way of getting closeup pictures of sky objects: attaching your camera to the telescope itself. Prime focus photography, as it's called, uses the telescope as a giant lens. This brings small objects like galaxies, star clusters, and nebulae relatively close and allows taking much longer exposures. Because the scope is tracking such a small field of view, however, it must be aligned accurately to the north celestial pole.

With precise polar alignment, shooting through the scope becomes relatively easy. Minor adjustments in tracking made with a drive corrector as the exposure runs its course will ensure sharp star images in the final picture.

Eyepiece Projection

A trickier technique called eyepiece projection enables recording planets on film. Though they are bright, planets are tiny and so need to be enlarged tremendously in order to reveal details on their globes. By inserting an eyepiece between the telescope and camera, the eyepiece further magnifies the planet's image onto the piece of film in the camera. The objective is to capture portraits of the Moon, Mercury, Venus, Mars, Jupiter, and Saturn. Uranus and Neptune can be captured by eyepiece projection but are so distant they appear only as tiny, blue-green balls. Tiny Pluto is too distant to photograph as a disk — it appears like a star even when magnified greatly.

Refer to the instructions that came with your telescope to judge how to approach eyepiece projection photography. It's a tricky approach, but one you will find satisfying after getting used to it.

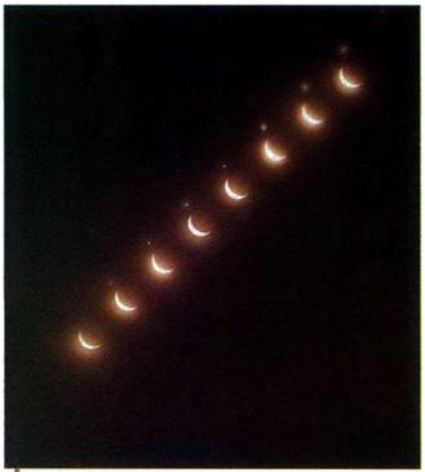
Shooting at such high magnification requires precise polar alignment. Minor corrections during the exposure must be made with a drive corrector. Focus critically and look through the camera's viewfinder to see the planet's sharp image. The seeing, or atmospheric steadiness, will vary considerably over timescales as short as a few seconds. Shoot the frames during the steadiest moments you can, and fire off an entire roll of film once the rig is set up. Exposure times vary greatly depending on the focal length of the system, but try 1/8-, 1/4-, 1/2-, 1, and 2 seconds to see what appears to work best for your system and film.

Whether you capture a constellation, a portrait of the Moon lying near Venus, or an image like that of a distant galaxy, astrophotography offers a deep and meaningful way to remember your nights under the stars. Don't be afraid to experiment, and always remember to check ASTRONOMY for details on different types of astrophotography. See you under the stars! ☐

Mark J. Coco is an astronomy writer, photographer, and lecturer living in Redondo Beach, California.

Painting with Light

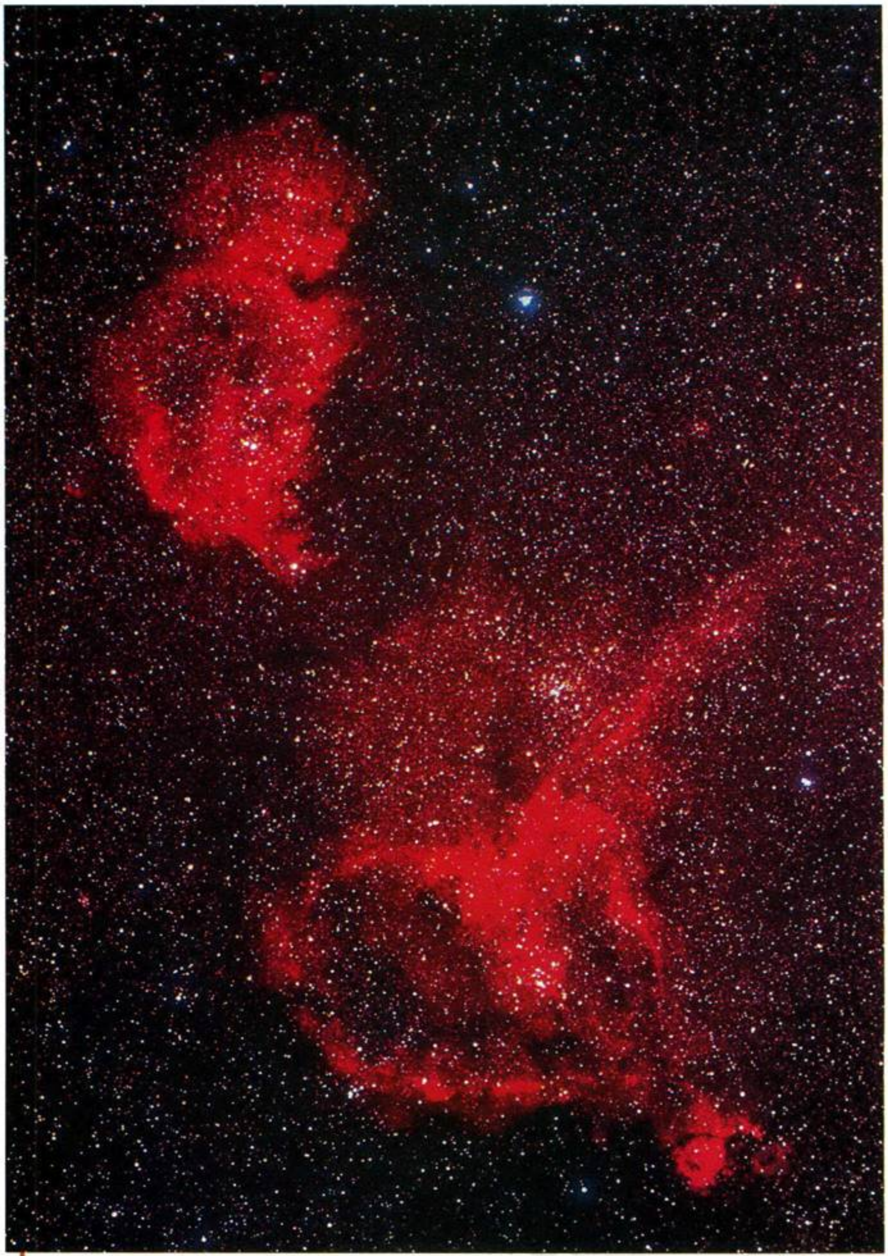
Subtle shades of the night sky's most beautiful features cascade into the cameras of backyard astrophotographers on every clear night. Here's a selection of the finest portraits of the sky ASTRONOMY has received over the past months.



The Moon and Venus Rise in Clouds

by Ronald E. Royer

(4-inch f/5 refractor, Ektachrome 100 film, Wratten 2A filter, 10-second exposures at 5-minute intervals on January 27, 1995, from Lakewood, California)



Emission Nebulae IC 1805 and IC 1848

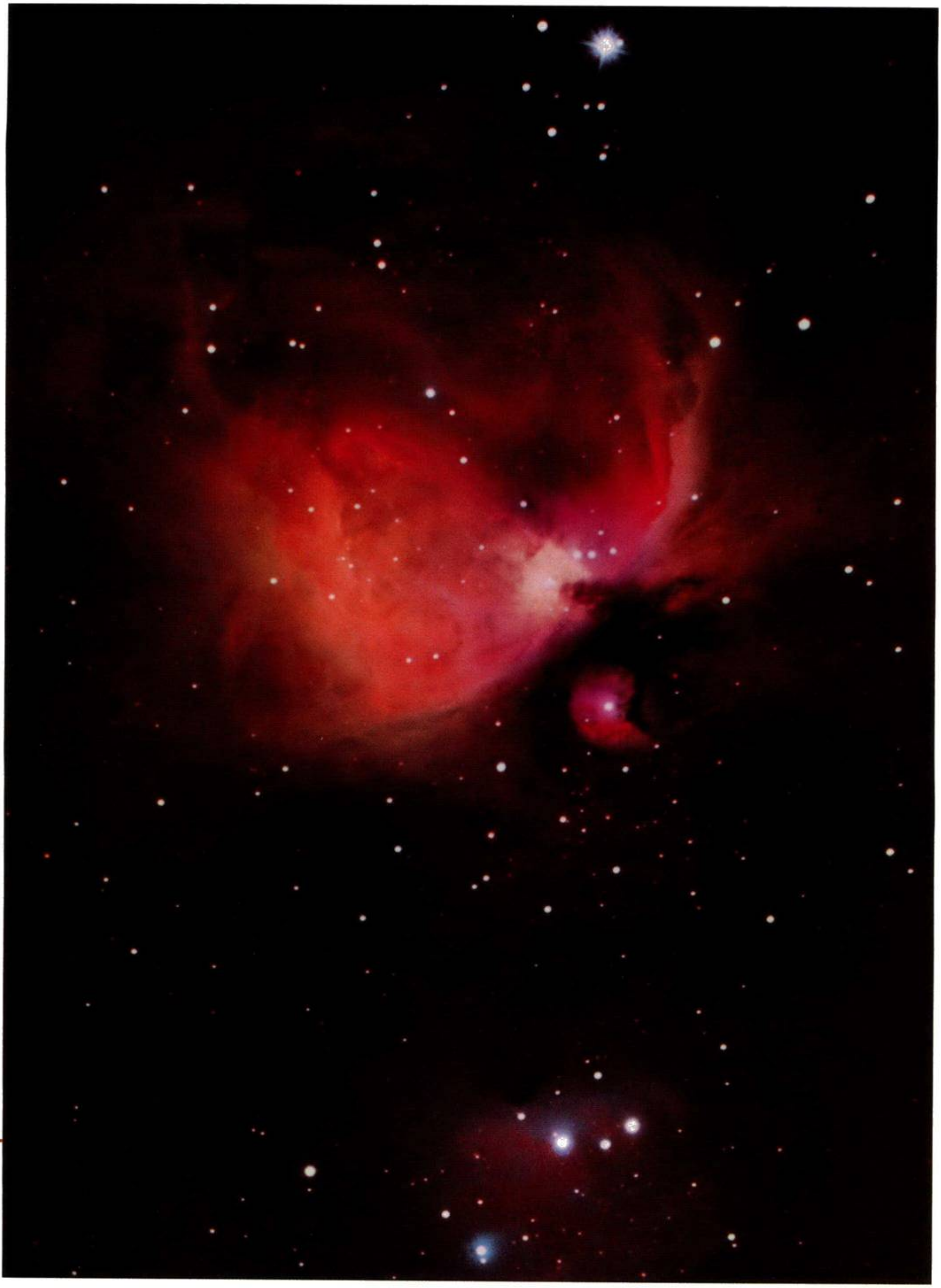
by Michael Stecker and James R. Foster

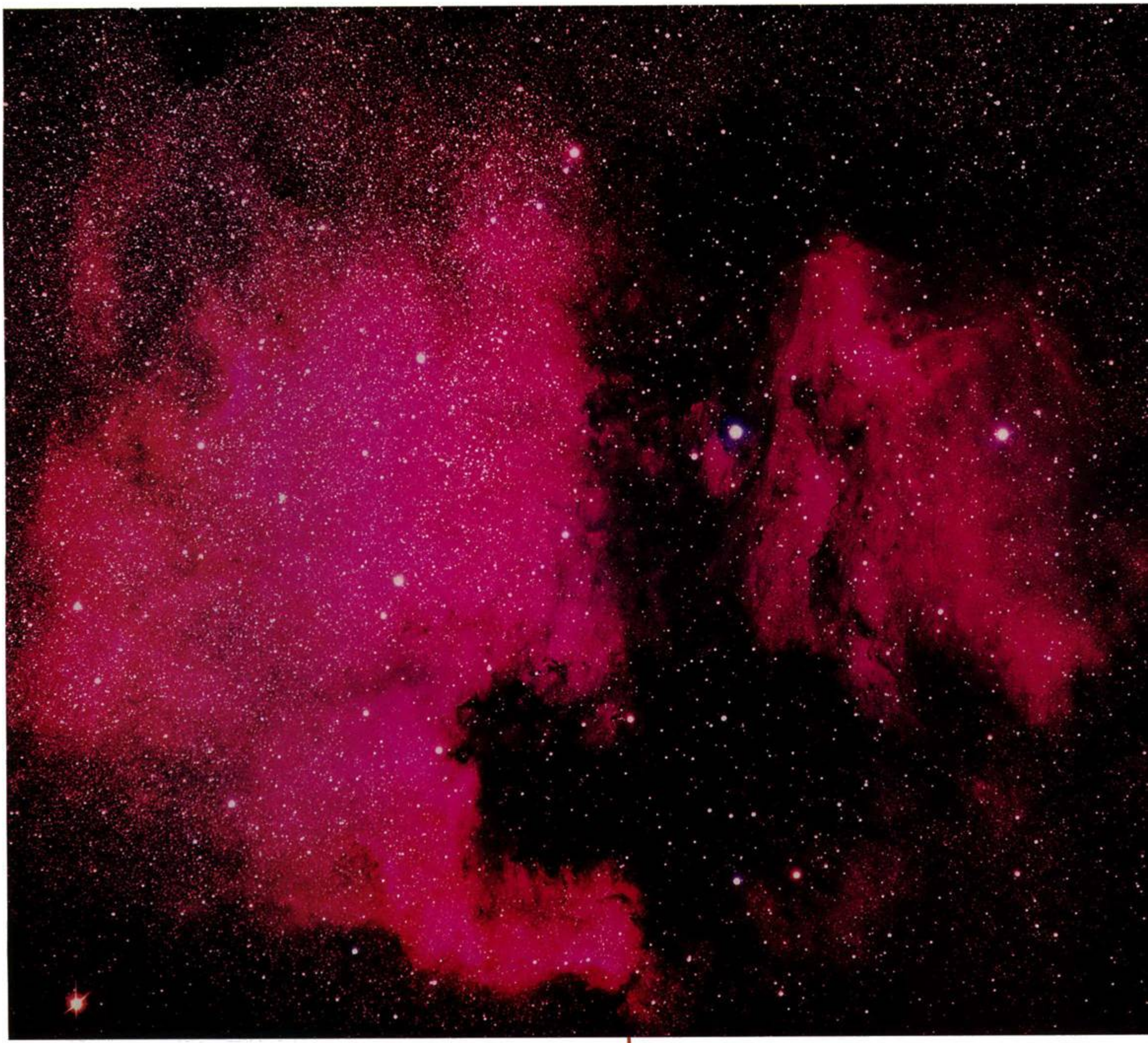
(300mm lens at f/2.8, hypersensitized Tech Pan film, tricolor composite using 60-minute red, 75-minute green, and 90-minute blue exposures)

The Orion Nebula

by Martin Bernier

(8-inch SCT at f/6, Kodak Royal 1000 film, Lumicon Deep-Sky filter, 45-minute exposure)

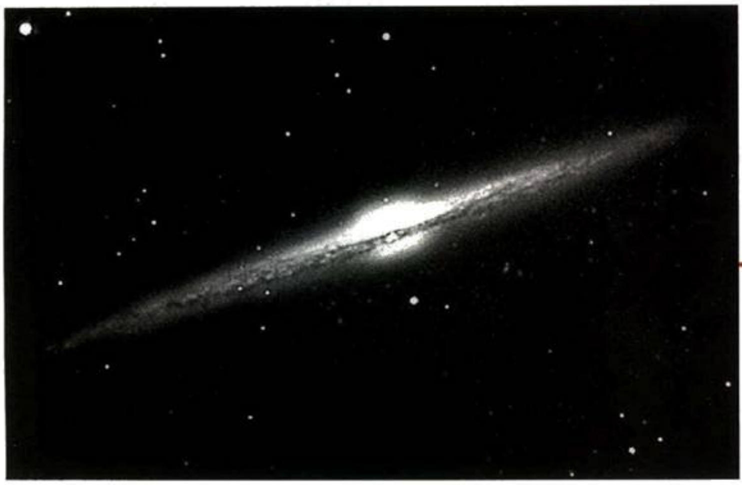




The North America and Pelican Nebulae

by George Greaney

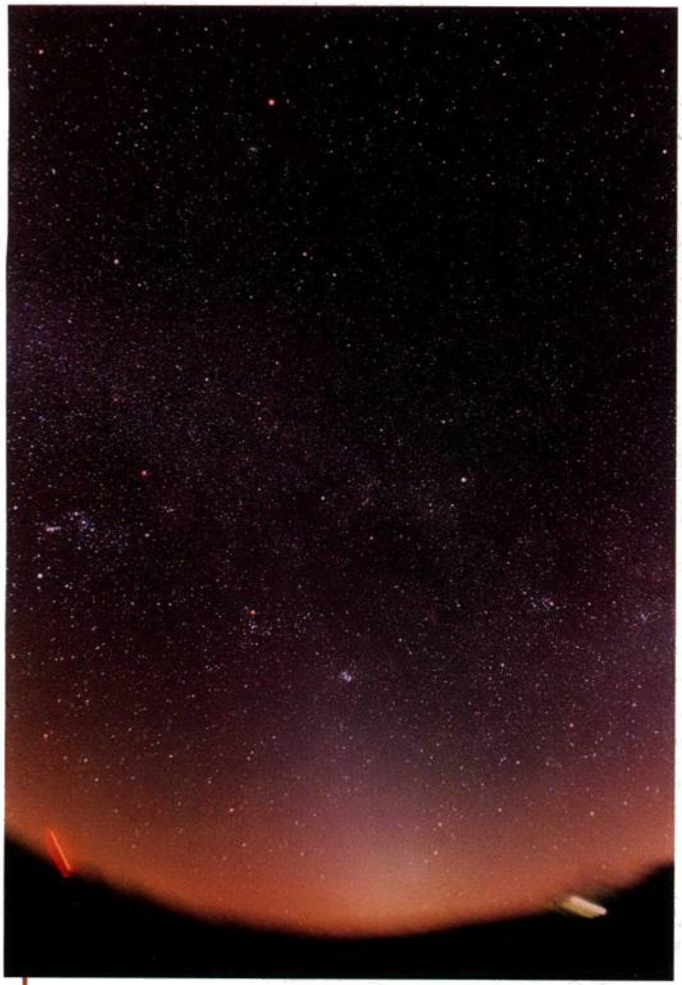
(6-inch f/7 apochromatic refractor, hypersensitized Fuji Super HG 400 film, composite of two 60-minute exposures)



Edge-on Galaxy NGC 4565

by Jack Newton

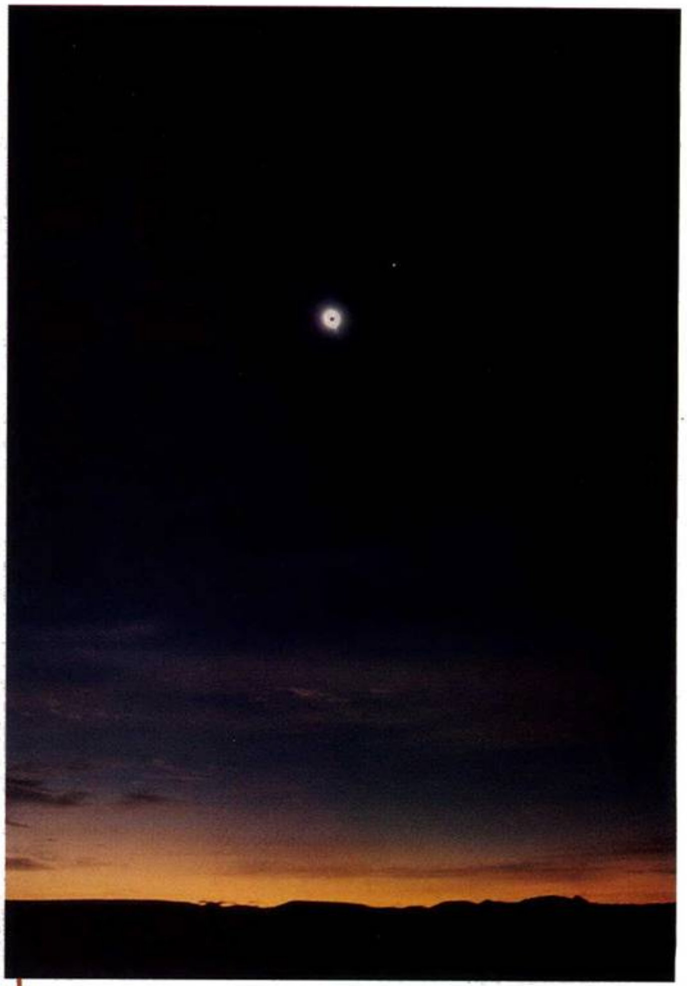
(25-inch f/5 reflector, Pictor CCD camera)



Zodiacal Light Brushes the Winter Milky Way

by Douglas C. Zubenel

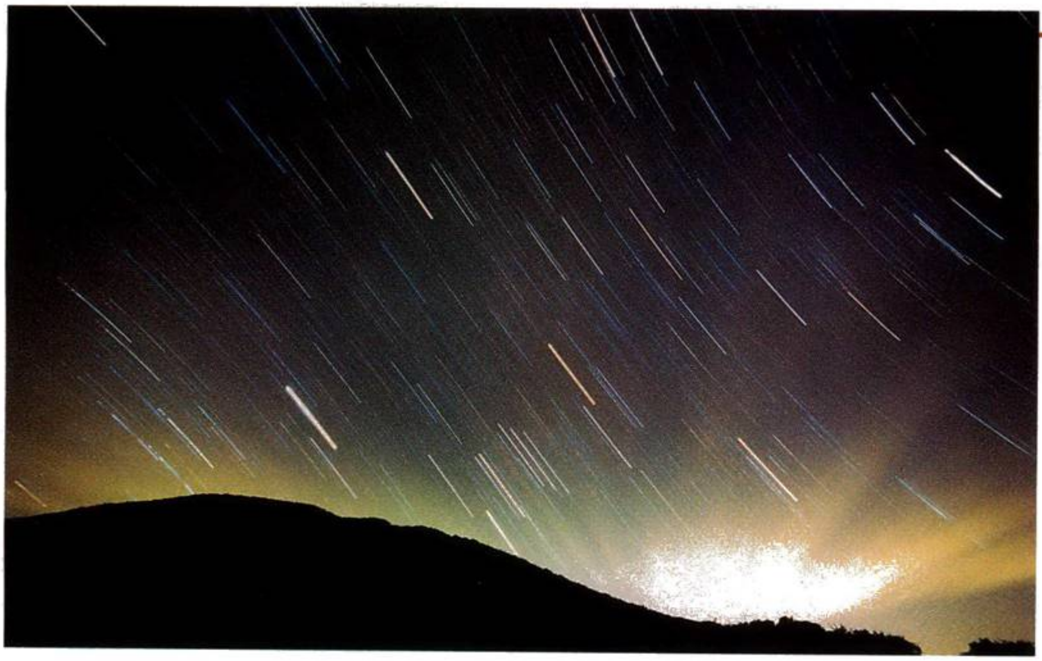
(16mm fisheye lens at f/2.8, Fuji Super G 400 film, 20-minute exposure on March 20, 1995)



Total Eclipse Over Bolivia

by Jim Manning

(28mm lens at f/4, Ektachrome 200 film, ¼-second exposure on November 3, 1994, from La Lava, Bolivia)

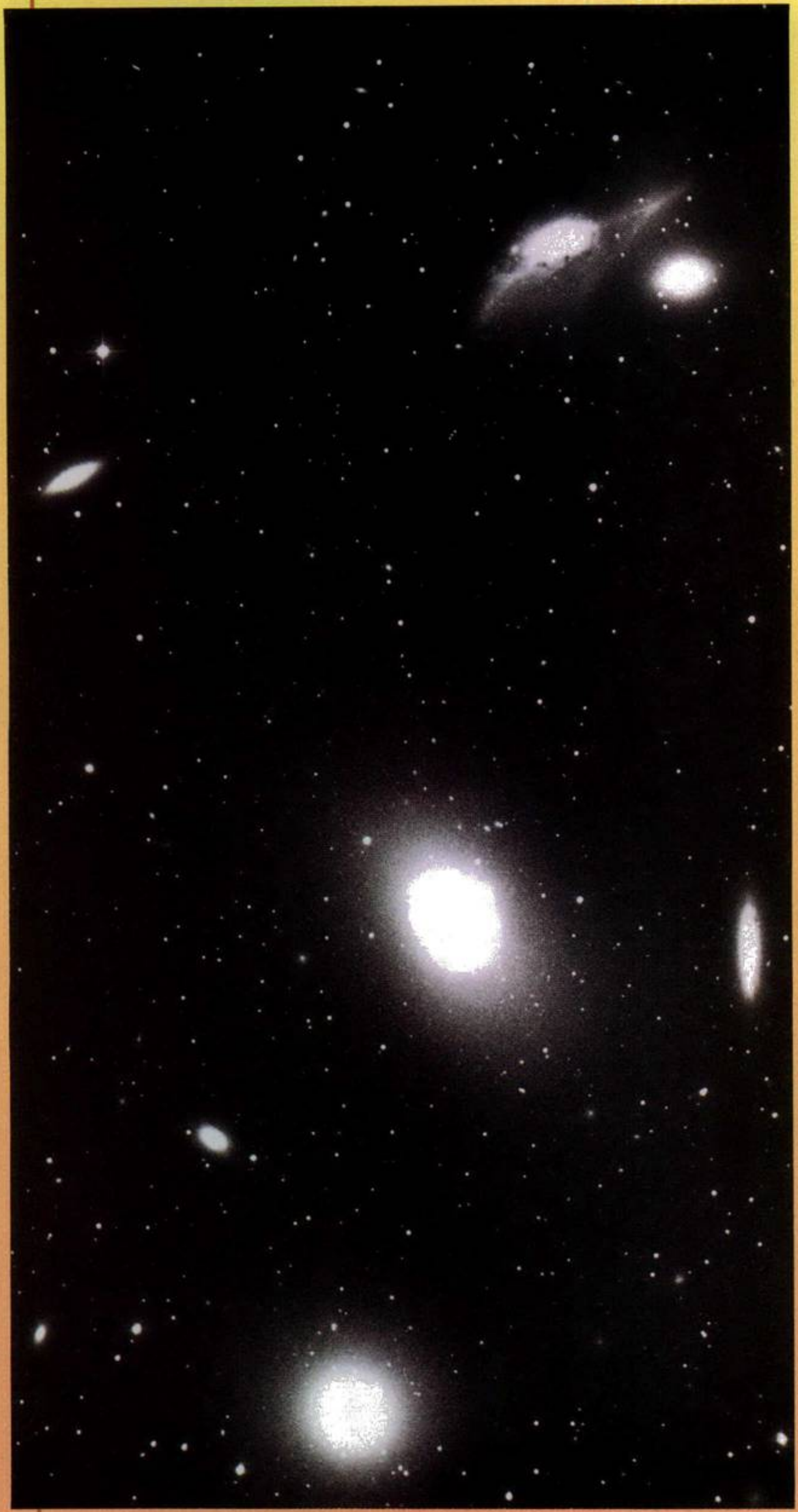


Cirrus Clouds Drift Across Trailed Stars

by Jerry Schad

(17mm lens at f/5.6, Ektachrome P1600 film at ISO 3200, 30-minute exposure)

Core of the Virgo Cluster



by Martin C. Germano

(14.5-inch f/5 reflector, hypersensitized Tech Pan film, 103-minute exposure)

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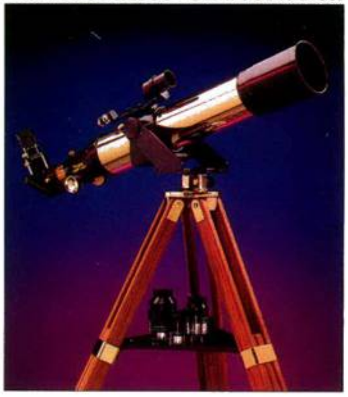

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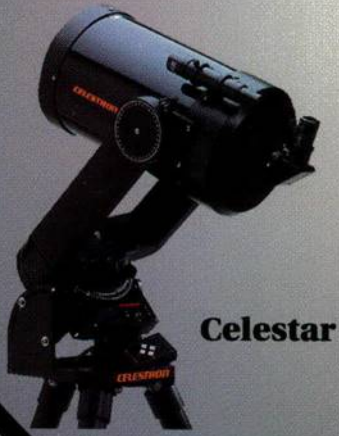

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